THE THORAX OF INSECTS AND THE ARTICULATION OF THE WINGS.

By ROBERT EVANS SNODGRASS,

Of the Bureau of Entomology, U. S. Department of Agriculture.

I. INTRODUCTION.

This paper is an attempt to show the unity of thoracic structure that prevails throughout all the orders of insects. It is hoped that it will be of special service to systematists in entomology and that it will meet with approval from students of morphology. The material on which the paper is based was all drawn from the U. S. National Museum and the dissections have been deposited in the museum.

The work has been done under the direction of Dr. A. D. Hopkins, of the U. S. Bureau of Entomology, and has grown from an attempt to determine thoracic homologies in the Coleoptera, especially in the family Scolytidæ. It is published by the approval of Dr. L. O. Howard, chief of the bureau, as a contribution from the office of Forest Insect Investigations. The author is indebted to Doctor Hopkins not only for the opportunity of carrying on the work but also for a great deal of help in doing it and for the verification of observations. Assistance has also been received from other members of the entomological staff of the bureau, among whom are Mr. Nathan Banks, Mr. A. N. Caudell, Mr. D. W. Coquillett, Mr. R. P. Currie, Dr. H. G. Dyar, Mr. Otto Heidemann, Mr. E. A. Schwarz, and Mr. H. S. Barber and also Mr. J. C. Crawford, of the U. S. National Museum.

Some of the drawings on the plates were used by the writer in a former paper on the thorax, published in the Proceedings of the Washington Entomological Society (1908), and are here reproduced with the permission of the editors of that journal.

No new theory is presented. The writer claims that the diagrams forming text figures 1 to 6 represent simply the facts. All schemes of thoracic symmetry in consecutive circles are discarded on the ground that they are supported only by the imagination.

The following statements sum up the principal conclusions:
(1) There is no reason for believing that the parts of any thoracic
segment are derived from more than one metamere, though the primitive thoracic region may have been composed of more than three
segments, remnants of the supernumerary ones being possibly represented by the intercalary plates of some of the Aptera; (2) the
thoracic sclerites are subdivisions of an original undivided segmental
wall; (3) the sclerites of the pleurum are homologous throughout all
the orders and modifications are brought about principally through
the coalescence of the pleurites; (4) the tergum consists of a primitive
undivided notal plate carrying the wings and, in the adult meso- and
metathorax of all the principal orders, except the Orthoptera, of a
second postnotal or pseudonotal plate developed in the membrane
behind the first and having no connection with the wings; (5) the
divisions of the notum are secondary, though similar in most of the
orders, and are not necessarily homologous, while modifications are
brought about through a stronger subdivision into distinct regions
and even into separate sclerites.

It is unfortunate for modern entomology that there are so many
species of insects. Entomologists early had to specialize as Coleopterists, Dipterists, Lepidopterists, and so in each order a scheme of
anatomy and a nomenclature grew up which satisfied the needs of
the worker in that order but had no necessary connection with those
of workers in other groups. It is true that Andouin in 1824 worked
out a system of comparative external anatomy and proposed a
universal set of names for the sclerites. It is true also that his names
have been in large part employed by nearly all subsequent entomologists. But in the actual application of Andouin's names to the sclerites of the thorax, specialists in the various orders have differed widely
on account of their ignorance concerning the correspondence of parts
in different insects. Recent entomologists who have attempted to
enforce a uniformity of nomenclature based on a more thorough
knowledge of insect structure are confronted with the nonconforming masses of literature which must form the basis of work by present
and future students in each order. However, even if systematists
never can employ a uniform system of names, it can not be denied
that it is best to know the true homology of the parts as far as this
can be determined.

It is impossible to follow the rule of priority in selecting anatomical terms, for the name must be descriptive of the part to which it
is applied. The earlier entomologists also paid little attention to
the duplication of parts in successive segments, but gave a separate
name to every piece. Andouin did away with this system in 1824
and firmly established a nomenclature based on the belief that each
thoracic segment is a modification of one plan of structure. He

should be taken as the Linnæus of thoracic nomenclature, and there is not sufficient reason on any ground for applying new terms to the parts he named.

In the study of the wings the venation nomenclature established by Comstock has been adopted. No attempt has been made to prove or to disprove Comstock's interpretations of the veins in the main part of the wing. While a study of the basal structure may show definitely that some particular vein is absent as a distinct trunk at the base, it still remains an open question whether this vein is actually gone or is fused with the one before or behind it. The general venation must furnish the evidence in most such cases.

II. THE SEGMENTATION OF THE HEAD AND BODY.

A few decades ago an insect was defined as a creature consisting of a head, a thorax subdivided into three segments, and an abdomen composed of 10 or 11 segments. Such a definition, however, would not satisfy the demands of most present-day entomologists, and it is interesting to contemplate the shock some antievolutionary forefather of entomology would receive could he now see in print the statement that an insect is composed of 40 segments. This said forefather might be in some measure pacified, however, were he to learn that the insects themselves have not been required to keep pace with the ideas of entomologists concerning them.

1. SEGMENTATION OF THE HEAD.

If the question as to how many embryonic metameres form the head of an insect could be decided by a vote among present and past students of the subject, the six-segment theory would undoubtedly be established. The problem of head segmentation has been attacked from both an anatomical and an embryological standpoint, but, since the embryologists attempt to discover the actual facts of development, it would seem that deference should be paid to their opinions. Furthermore, the embryologists agree more closely among themselves than do the anatomists. Although the number of head metameres claimed by the former varies from four to seven, this discrepancy is not what it appears to be in figures, for the chief point of disagreement is whether the three preoral segments apparent in the embryo are actual metameres or are only secondary divisions. The real question is thus reduced to one between six and seven segments.

On the other hand, the anatomists describe from four to nine segments without any alleviating circumstances. The number of theories seems to agree closely with the number of theorizers. Comparative anatomy as a key to morphology has been so thoroughly deposed in vertebrate craniology that we must regard it with great suspicion in

entomology. On the other hand, its advocates may, of course, point out that adult insects are so specialized that even the embryo in many respects does not repeat phylogeny. Yet it has never been shown that the head is a case in point. It certainly at an early embryonic stage consists of a series of segments and no evidence has been offered to prove that these embryonic segments are not true metameres.

The principal anatomists who have mapped out the head on purely anatomical grounds are Newport (1839), Janet (1899, 1900), and Verhoeff (1905). Newport went at the subject in the simplest manner possible. He virtually drew circles around the head corresponding with the plates of the dorsal surface, namely, (1) the labrum, (2) the clypeus, (3) the front (clypeus posterior), (4) the small sclerites sometimes found about the bases of the antennæ, and (5) the epicranium. He thus had five segments which were composed laterally and ventrally by whatever fell between two of the inclosing lines.

Later anatomists have not been satisfied with this direct and simple arrangement by Newport. Janet (1899, 1900) makes out nine head segments which he arranges in three sets of three each and then points out the nice conformity in which the set of three thoracic segments follows. He does not even intimate, however, by what natural law the head should be a multiple of the thorax, or why his theory should be more plausible by making it such.

Verhoeff (1905) discredits embryology as a guide in the study of the morphology of the insect head, and, on purely anatomical grounds, elaborates a scheme of eight segments for the head of the Dermaptera. The labrum, the clypeus, and the front, according to his plan, are the first three terga, while the sterna of these segments form the epipharyngeal membrane and the anterior part of the throat. These segments constitute the " protocephalon." Following them are an antennal segment (a preantennal segment being absent in Dermaptera), and a premandibular segment, constituting the " deutocephalon." Finally, the three jaw segments form the " tritocephalon." The mentum and submentum form the sterna of the labial and maxillary segments, respectively. This view assumes that the maxillæ originate *behind* the labial palpi. In the Chilopoda the so-called maxillæ are much more like the ligula and labial palpi of insects than like the insect maxillæ, while the chilopod labium consists principally of the leg-like palpi, thus suggesting that the hexapod first maxillæ are the chilopod second maxillæ. If this should be true, then the theory advanced by Banks (1893) that the poison fangs have coalesced with the second maxillæ in Chilopoda to form the first maxillæ of Hexapoda appears more possible. Otherwise, Banks had to assume that the poison claws moved forward past the bases of the second maxillæ and then fused with the first maxillæ. A combina-

tion of the poison claws and the labial palpi of the chilopods would form an organ much more nearly resembling the insect maxillæ than would a union between the poison claws and the first maxillæ of chilopods.

All reasoning of this fascinating sort, however, simply shows the limitless extent to which morphological theorizing can be carried on anatomical grounds.

Verhoeff's theory of head segmentation has been severely criticised by Heymons (1905) on the ground that the facts of embryology utterly refute it, and that it does not conform with the segmentation of the nervous system.

The simplest embryological view holds that there are four segments in the head—a preoral, a mandibular, a maxillary, and a labial segment. This is advocated by Lowne (1892), who regards the three embryonic divisions of the preoral region as secondary. Bengtsson (1897, 1905) adopts this view concerning the preoral region, but he finds four segments in the postoral part of the head. Almost all students of the embryology of the insect head, however, regard the three preoral divisions as true metameres. Hence, embryologists are divided in opinion mainly between six and seven head segments. The principal advocates of six segments are Zaddach (1854), Huxley (1878), Viallenes (1887), Wheeler (1893), Heymons (1895), Packard (1898), Riley (1904), and Holmgren (1904, 1907). The advocates of seven head segments are Folsom (1899, 1900) and Comstock and Kochi (1902). But these authors are supported also by Bengtsson (1897, 1905) and by Börner (1904) in so far as they find four postoral segments, though they recognize only one preoral segment.

The seven-segment theory is based mainly on Folsom's (1900) observation that seven pairs of ganglia appear in the head soon after involution, and that in *Anurida maritima* a pair of appendages or "superlinguæ" appear back of the mandibles, corresponding with the fourth pair of ganglia. These appendages fuse in most insects with the lingua of the embryo to form the hypopharynx of the adult, but in many lower forms they remain as the lateral lobes of the hypopharynx or "endolabium" and have been misleadingly called the "paraglossæ." Börner (1904) finds that the hypopharynx of nearly all insects having incomplete metamorphosis is a compound structure formed of the median "glossa" and the lateral paired elements, which he calls the "maxillulæ." (The reader must remember that the terms "glossa" and "paraglossæ" have been inconsiderately applied by some recent entomologists to the parts of the hypopharynx or "endolabium," while they properly belong to the outer or true labium.) Börner thus recognizes four postoral segments. Hansen (1893) suggested that the "paraglossæ" (superlinguæ, maxillulæ) of

Machilis are homologous with the first maxillæ of Crustacea, and Folsom concurs in this view. Apparently no one has compared them with the paragnatha of Crustacea.

Holmgren (1907), on the other hand, claims that these superlingual processes arise from the premandibular segment and are innervated from the tritocerebrum. It would seem that he must refer to a different pair of appendages, namely, the second antennal rudiments or " intercalary appendages." His observations were made on a fly larva (*Phalacrocera*).

Bengtsson (1897, 1905), however, describes an endolabium in *Phalacrocera* which includes " paraglossæ," equivalent to the superlinguæ of lower insects. Holmgren (1907) refutes this idea entirely, and claims that Bengtsson's so-called endolabium of fly larvæ is not the endolabium of lower insects but simply the terminal lobes of the ordinary outer labium, of which Bengtsson's " ectolabium " is the mentum and submentum. He furthermore asserts that what Bengtsson takes for nerves going to this endolabium from the superlingual ganglion are simply muscle fibers, though Bengtsson (1905) had stoutly defended his former observations (1897).

The best summarized statement of the segmentation of the head is that made by Comstock and Kochi (1902). Although some work has been done since, but little new information has been added. The preoral part of the head consists of three embryonic segments corresponding with the three lobes of the brain, namely, the protocerebrum, the deutocerebrum and the tritocerebrum. The first segment has no appendages, but it innervates the eyes; the second is the antennal segment; the third carries the " intercalary appendages "—vestigial organs observed by many embryologists in the Aptera (Wheeler 1893, Uzel 1897, Claypole 1898, Folsom 1900), possibly in the Diptera (Holmgren 1907), and in the Hymenoptera (Bütschli 1870). These rudimentary appendages correspond with the second antennæ of Crustacea.

The postoral region of the head and the mouth parts are certainly derived from at least three embryonic segments, or, according to many embryologists, from four. The first is the mandibular segment. The possible second is the one under dispute, but so many embryologists have described two small appendages back of the mandibles which fuse with the median lingua to form the hypopharynx that their existence can not be doubted, and it is reasonable to suppose they represent a segment. Riley (1904), however, shows that these superlingual appendages, or maxillulæ, are absent in the embryo of *Blatta*, and he doubts that they are actual appendages where observed. Berlese (1906) also does not recognize a superlingual segment. Following this doubtful metamere is the segment of the first maxillæ, and finally that of the second maxillæ or labium.

Comstock and Kochi (1902) attempt to assign the various head sclerites of the adult to individual segments of the embryonic head. Riley (1904) in studying the cockroach arrives at different results, but he discredits the reliability of all attempts to map out the adult head according to segments. In discussing Comstock's view, he says: " My results have convinced me that so intimate a relation between primary segmentation and the sclerites can not be shown."

Of course, the ventral part of the preoral region becomes dorsal so that the mouth, which is originally on the middle of the ventral surface of the head, comes to be situated anteriorly. Thus the labrum, clypeus, and front are developed from a primitive ventral surface. So, in a general way, the other sclerites arise from definite regions, but they are simply secondary divisions of a continuous head capsule, and the notion that they are modified terga, pleura, and sterna of the head metameres appears to be entirely unsupported by actual evidence.

The last head segment is the one that chiefly concerns us in a study of the thorax. All embryologists seem to agree that its body forms the sclerites found in the neck of the adult and that only its fused append-ages, the labium, become asociated with the head, except when there is a gular plate present, which sclerite is derived from its sternum. This embryonic segment can, therefore, hardly be spoken of as a head metamere. It is the segment of the neck and this, in the adult, has received the name of " microthorax."

Hence we would accept six primitive head segments, providing the apparent superlingual segment is a real one, and one microthoracic or neck segment.

2. SEGMENTATION OF THE BODY.

The foregoing discussion of the segmentation of the head has been made more extensive, perhaps, than a mere introduction to the study of the thorax would require. But the writer wishes to illustrate to anyone not familiar with the subject the utter futility of attempting a study of metamerism on an anatomical basis. The embryology of the thorax has never brought out much more than that three segments compose it, except in the Hymenoptera, where the first abdominal segment is fused with the thorax. Hence there are no embryological facts concerning the thorax by which anatomists can be held in check, but, with the unfortunate example of both the vertebrate and the insect head in mind, one must certainly regard with much doubt all theories of thoracic metamerism based on a study of the plates form-ing the very apparent three segments in the adult. Riley (1904) makes the following appropriate statement :

It would seem that the definitive sclerites can afford little or no evidence as to the primary segmentation of insects. This is certainly true of the head sclerites

and I see no reason why it should not apply to other regions of the body. Sclerites originate from mechanical causes and do not necessarily have any relation to the primary segmentation.

Lowne (1892) in discussing the prevalent notion of the dual structure of the thoracic segments states that he does not admit it proved, and does not see that it helps in the understanding of the morphology of the insect segment.

The writer, then, wishes to say emphatically that he discards everything but plain statements of the facts in the description of the thorax. Since, however, modifications of the same plan of thoracic structure recur throughout the insect orders, this fact can be taken as evidence that all the sclerites, especially those of the pleurum, have not been produced independently in the different orders.

Many writers have supposed that each thoracic segment consists of two united segments. The arrangement of the plates on any typical segment would suggest this—the dividing line on the side passing between the episternum and the epimerum, on the back between the scutum and scutellum, and on the venter between the sternum and sternellum. Some authors have adduced further evidence of the dual nature of the segment from the apparent division of the coxa in some orders into an anterior and a posterior part.

Banks (1893), arguing from the coalescence of segments in the Chilopoda, concluded that the thorax of insects is formed of five segments, the first, third, and fifth retaining the legs, the second and fourth bearing the wings. He regards the coxæ as double and cites the meso- and metacoxal appendages of *Machilis* as examples of remnants of the ventral appendages of segments two and four. He points out that in *Scutigera* (the highest chilopod) the small terga, after the first segment, are united with the larger ones so that the first segment bears only one pair of legs while the following bear two pairs each. It is only a step from this to suppose that in *Machilis* the second leg of each pair has become rudimentary, forming the coxal appendages, while the first of each pair has persisted as the functional walking appendage. Banks does not seem to regard the cervical sclerites of insects as representing a segment in the thoracic series.

Patten (1890) gave other reasons for regarding each segment as double, adduced from a study of the mouth parts and the nerves.

Walton (1900) still further supports this theory by a study of the coxæ. He concludes that in both the Chilopoda and the Hexapoda the coxa is composed of an anterior part, " coxa genuina," and a posterior part, " coxa meron." These two coxal segments falling in line with the episternum and epimerum, and the arrangement of the thoracic muscles, form his basis for believing the entire segment a compound of two primitive segments.

Now, it is only in the mesothorax and metathorax of Mecoptera Neuroptera, Trichoptera, and Lepidoptera that the coxa is actually a double structure. In these orders the coxa genuina of Walton carries the trochanter, while the coxa meron is attached to the coxa genuina only. In other orders in which the coxa shows a more or less evident division this division is in the coxa genuina itself, the coxa meron being absent, and is of the nature of a strengthening of the coxa by opposite ridges on its inner walls. In the Neuroptera and Trichoptera at least it can easily be demonstrated, by a study of larval and pupal forms, that the " coxa meron " is simply a detached extension of the epimerum, which fuses upon the posterior side of the true coxa. It is, hence, not a part of the primitive coxa at all, and the apparent double coxa in these orders is a purely secondary condition. (See special descriptions under Neuroptera, p. 564, and Trichoptera, p. 565, also p. 542 and figs. 144–148.)

Comstock and Kochi (1902) show that the plates of each segment may be arranged into two subsegments, but defer any opinion as to whether they represent two primitive segments or not.

It will be found that all these theories are purely imaginative. Embryologists have not shown that the plates of any thoracic segment are derived from more than one metamere. However, it may be true that two, three, or four segments primarily existed where there is but one in insects as we now know them. Verhoeff (1902, 1903, 1903a, 1903c, 1904, 1904a) is the principal elaborator of this theory.

Verhoeff bases his ideas on a study of the Aptera, the Embiidæ, and the Dermaptera, and especially on a comparison of *Japyx* with the Chilopoda. He first points out the tendency in the Chilopoda toward the suppression of every alternate segment by a fusion with the preceding larger spiracle-bearing segment. In *Japyx* there are remnants of extra segments between the pro- and mesothorax, and between the meso- and metathorax, represented principally by well-developed tergal and sternal plates. Thus the thorax would consist of six segments in three pairs, namely, the microthorax and prothorax, the stenothorax and mesothorax, and the cryptothorax and metathorax. Verhoeff observes, however, that this arrangement does not correspond with that of the Chilopoda, because the small segment in *Japyx* is associated with the large segment following instead of with the one preceding. Then, as if to remedy this discrepancy, he further discovers traces of still other thoracic segments, one between the stenothorax and the mesothorax and another between the cryptothorax and the metathorax. Finally, by the aid of small presternal plates (" vorplatten ") he is able to construct the following table of complete uniformity in segmentation between Scolopendridæ and Japygidæ (Verhoeff, 1904a) :

SCOLOPENDRIDÆ.	JAPYGIDÆ.
Head.	Head.
Maxilliped segment.	Microthorax.
First leg-bearing segment.	Prothorax.
Intercalary segment.	Presternal plates (vorplatten).
Second leg-bearing segment.	Stenothorax.
Intercalary segment.	Small intercalary ring.
Third leg-bearing segment.	Mesothorax.
Intercalary segment.	Presternal plates (vorplatten).
Fourth leg-bearing segment.	Cryptothorax.
Intercalary segment.	Small intercalary ring.
Fifth leg-bearing segment.	Metathorax.
Intercalary segment.	Presternal plates (vorplatten).

Thus, it is supposed that *two pairs* of Scolopendrid segments—a leg-bearing and an intercalary segment in each pair—have been reduced to *one segment* in ordinary insects. This reduction has resulted not from a combination of segments but from a suppression first of the intercalary segments of the chilopod and then of the alternate remaining leg segments. The intercalary segments of Scolopendridæ, in other words, are not the small segments of *Japyx*, but are the much more rudimentary traces of segments between these and the large segments. Verhoeff's own statement (1903c) is as follows:

The intermediate segments (zwischen-segmente) of insects are reduced primary segments, inherited from Chilopodan ancestors and which have united into a double segment with the large primary segment immediately behind, while the intercalary segment of the original double segment of the Chilopods has become almost entirely extinct.

According to this theory, then, the primitive thorax consisted of ten segments. However, all but three of these have been eliminated in all but the very lowest insects, and the eliminated segments have taken no part in the formation of the plates of the body wall in present-day insects. It is certainly no difficult matter to show that the sclerites are formed during postembryonic growth and are purely secondary divisions of the body wall of one segment. Hence, this theory of Verhoeff's is entirely tenable, since it deals only with conditions which are presumed to be obliterated before the thoracic plates begin to form.

However, it must be admitted that all this elaborate scheme is based on an excessive use of the imagination. No proof is adduced to show that the intermediate and intercalary sclerites of *Japyx* are not secondarily developed plates or even subdivisions of the principal segments. Desguin (1908), in reviewing this notion of the multiple nature of the thorax in Aptera, concludes that neither the anatomical nor the embryological evidence is sufficient to prove whether these intermediate sclerites represent true segments·or not. Börner (1903) also gives a good criticism of some of Verhoeff's extravagant theories.

Verhoeff extends his view of the many-segmented structure of the insect body to the abdomen (1903a, 1903c, 1904). Here he finds, in the region of the first seven ordinary segments, seven primary segments and seven secondary ones. Beyond these are two genital segments, then the segment carrying the cerci, and finally, in the lowest insects, traces of three more beyond the last—the pygidium, the metapygidium, and the telson. The gonapophyses and the cerci are carried by the fifteenth, sixteenth, and seventeenth primitive segments, which are the eighth, ninth, and tenth persisting segments. Verhoeff thus makes out a total of twenty abdominal segments. Add to these the ten thoracic segments, one microthoracic segment, and nine head segments, and an insect assumes the dignity of a creature of forty segments!

III. THE MICROTHORAX.

Embryologists have shown that the sclerites of the neck, the second maxillæ of the head, the hind part of the subœsophageal ganglion, and the gular plate, when present, are all derived from one metamere. They usually reckon this metamere as the last segment of the head, while anatomists call its cervical parts in the adult the *microthorax*. This term has become pretty well established and will be adopted in the present paper, but not implying that it is a part of the true thorax. On the other hand there is no reason for calling it a head segment. In many of the lower insects its appendages, the second maxillæ or labium, are not attached to the head but are suspended from the gular membrane and associated much more closely with the microthoracic sclerites than with the head (*Spodromantis*, 25, *Sm.*). The fact that the microthoracic ganglion is fused with the true head ganglia preceding it signifies nothing more than does the fusion of the first abdominal ganglion with that of the metathorax. It is only when the sternal plate becomes transferred to the ventral surface of the head, as the gula, that the microthorax takes any part in the actual formation of the head.

Verhoeff (1902) regards the segment of the maxillipeds or poison claws in the Chilopoda as the equivalent of the microthorax in insects. This, however, is denied by Silvestri (1902), who says that the maxilliped segment of the Chilopoda is the prothorax of insects. Verhoeff (1903b) then further shows that in *Scolopendra* there are four pairs of nerves going to this segment, of which the second is the largest and innervates the appendages. In *Polypsilota striata*, a Mantid, he discovers the same four pairs of nerves arising from the subœsophageal ganglion back of the labial nerves and going to the microthorax and salivary glands. Here, however, the second is the weakest and obviously because there are, according to Verhoeff's view, no microthoracic appendages, the labium not being regarded as such.

There is evidently a lack of harmony here unless it be that the first maxillæ of the Chilopoda correspond with the superlinguæ of the Insecta, the second maxillæ with the maxillæ, and the poison claws with the labium. In this case we could regard the microthorax of insects as the maxilliped segment of the Chilopods, which, from superficial appearances, would not seem impossible.

The sclerites of the microthorax are well known. They have been studied extensively by Verhoeff (1902) and occur in nearly all the orders of insects. They are specially well developed in the Odonata (5, 6, 7, 8, 9, 12, *Mi* and *1 mi, 2 mi, 3 mi, 4 mi*), in the Orthoptera (24, 25, 36, 37, 45), and in the Euplexoptera (93), but occur in a more reduced condition in many of the other orders, such as the Coleoptera (95, *Mi*) and the Diptera (174, *mi, mi*). In the Orthoptera and Euplexoptera they often form an almost complete segment presenting tergal, pleural, and sternal plates. Verhoeff has gone so far as to identify all the pleurites of a thoracic segment in the microthorax, but undoubtedly this is establishing homologies on a too imaginative basis. Comstock and Kochi (1902) regard the gular sclerites of the head as the microthoracic sternum, and in some of the Euplexoptera (93) the microthoracic sternites are so large and so associated with the head as to suggest the gular sclerite of the Coleoptera.

We may conclude that there is no reason for regarding the microthorax as anything more than the neck segment whose sclerites are reduced to the small neck sclerites and the gular plate when the latter is present, whose ganglion has fused with the last head ganglion, and whose fused appendages become attached to the head in most cases and constitute the labium. It should not be included, in reckonings of the number of segments forming the head, as one of the head segments. (See note on page 595.)

IV. THE THORAX.

In a former paper (1908) the writer gave a brief account of the structure of the insect thorax. This description can now be amplified by illustrations taken from all the principal orders. For convenience the subject will be divided under three heads, namely, (1) the tergum, (2) the pleurum and coxa, and (3) the sternum.

1. THE TERGUM.

The word *tergum* is here used to designate all the chitinized parts of the dorsum of any segment. It is generally used interchangeably with the term "notum," but where the tergum consists of two plates the latter name, *notum*, will be restricted in this paper to the first or wing-bearing sclerite, and the term *postnotum* or *pseudonotum* (Verhoeff, 1903) applied to the posterior or post-alary plate. The notum is the plate which, by diversities of its surface topography,

becomes divided into the more or less definite regions usually called
the *prescutum*, *scutum*, and *scutellum*, while the postnotum remains
undivided and is the *postscutellum*. The postnotum does not occur
in the Orthoptera; it does not occur in the nymphs of any insects,
even though well developed in the adults; it does not occur in the
pupæ of Neuroptera and Coleoptera at least; and it is never present
in the prothorax. Therefore it is most probably not a primitive
tergal plate, and the term *pseudonotum* fits it very well. Verhoeff
(1903) gave this name to the postnotal plate of the Euplexoptera
(Dermaptera), though he may not have intended its general use in
the sense here applied.

Text figures 1 and 2
diagrammatically rep-
resent the relation
of the notum (*N*)
and the pseudonotum
(*PN*) to each other
and to the wing, the
last being carried en-
tirely by the notum.
Fig. 3, representing a
segment in side view,
shows the pseudo-
notum continuous lat-
erally with the epi-
merum (*Epm*). This
is the most frequent
condition, though
often there is a line
between the two and
sometimes they are
only articulated or
merely contiguous.

FIG. 1.—DIAGRAMMATIC TERGUM OF ANY COMPLETE WING-
BEARING SEGMENT, AND THE BASE OF THE WING,
DORSAL VIEW; *1A*, FIRST ANAL VEIN; *ANP*, ANTERIOR
NOTAL WING PROCESS; *anr*, LINE OF ANTERIOR VEN-
TRAL NOTAL RIDGE (*ANR* OF FIG. 2); *AxC*, AXILLARY
CORD; *AxM*, AXILLARY MEMBRANE; *C*, COSTA; *Cu*,
CUBITUS; *Em*, LATERAL EMARGINATION OF NOTUM;
M, MEDIA; *Mb*, MEMBRANE BETWEEN NOTUM AND
PSEUDONOTUM; *N*, NOTUM; *PN*, PSEUDONOTUM OR POST-
NOTUM; *PNP*, POSTERIOR NOTAL WING PROCESS; *pnr*,
LINE OF POSTERIOR VENTRAL NOTAL RIDGE (*PNR* OF
FIG. 2); *Pph*, POSTPHRAGMA; *R*, RADIUS; *Sc*, SUB-
COSTA; *Tg*, TEGULA; *v*, LINE OF MEDIAN OR V-SHAPED
VENTRAL NOTAL RIDGE (*V* OF FIG. 2).

This figure and figure 2, giving a ventral view of the tergum, both
show the postphragma (*Pph*) depending from the posterior edge
of the pseudonotum, though it is often restricted to the middle of the
latter.

The pseudonotum always carries the postphragma. Verhoeff re-
gards it as a development of the postphragma, but it is probably
a better statement of the facts to say that the phragma is a develop-
ment of the pseudonotum, for in the lower insects the latter is a
large flat plate, while the phragma may be simply a thin fold pro-
jecting downward from its posterior edge. In the mesothorax of
Lepidoptera, Hymenoptera, and Diptera this condition, however,
is reversed, the phragma being developed to a great size, although the
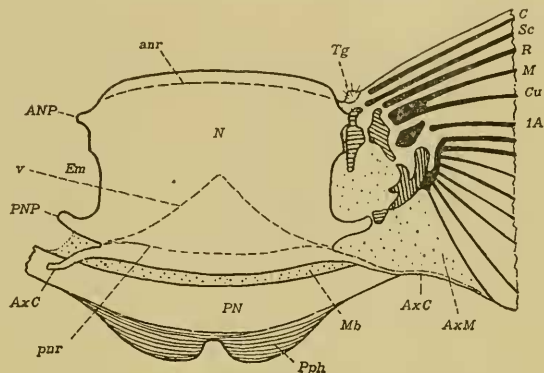pseudonotum itself is not reduced. The postphragma is really a

chitinization of the infolded intersegmental membrane behind the pseudonotum, for it is always composed of two closely appressed or fused laminæ. The first is directly continuous with the pseudonotum, the second is connected with the notum of the segment following, generally by membrane but sometimes directly, as when the segments are fused.

The pseudonotum is conspicuous in the metathorax of Coleoptera (132–140, *P.N*). It is the plate that Straus-Dürckheim (1828) named the "tergum" in *Melolontha vulgaris* (135, *P.N*), but most authors have followed Audonin (1824) and Newport (1839) in calling it the "postscu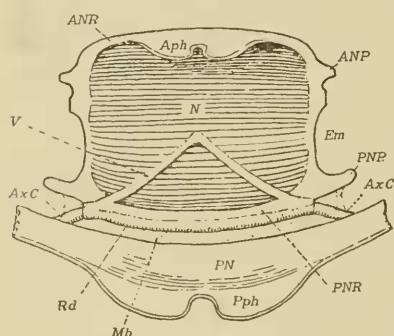tellum." This name is appropriate when a scutum and scutellum can be distinguished. Berlese (1906) recognizes and figures the plate in the Coleoptera, but he refers it to the abdomen, calling it the "acrotergite" of the first abdominal segment. Such a disposition of the sclerite, however, is clearly impossible on account of its intimate connection, an articulation (*i*) in beetles, with the epimera of the metathorax. In the mesothorax of Coleoptera there is no pseudonotum unless the two small plates (127, 128, 131, *q*) yoking the mesonotum to metanotum are rudiments of it. The pupæ of beetles do not show a pseudonotum even in the metathorax. In *Dendroctonus valens* (122, 126), and in *Tetropium velutinum* (123) it is easy to see that no pupal plate intervenes between the metathoracic notum or wing-bearing sclerite (*N₃*) and the first abdominal tergum (*1T*). The latter can be identified by the first abdominal spiracles.

FIG. 2.—DIAGRAMMATIC TERGUM OF ANY COMPLETE WING-BEARING SEGMENT, VENTRAL VIEW; *ANP*, ANTERIOR NOTAL WING PROCESS; *ANR*, ANTERIOR NOTAL RIDGE; *Aph*, PREPHRAGMA; *AxC*, AXILLARY CORD; *Em*, LATERAL EMARGINATION OF THE NOTUM; *Mb*, MEMBRANE BETWEEN NOTUM AND PSEUDONOTUM; *N*, NOTUM; *PN*, PSEUDONOTUM; *PNP*, POSTERIOR NOTAL WING PROCESS; *PNR*, POSTERIOR NOTAL RIDGE; *Pph*, POSTPHRAGMA; *Rd*, POSTERIOR REDUPLICATION OF THE NOTUM; *V*, V-SHAPED VENTRAL RIDGE OF NOTUM, THE ENTODORSUM.

In the Plecoptera the pseudonotum is a large, simple plate in both the meso- (75) and the metatergum. It is partly overlapped by the notum (*N*). In a nymphal tergum, however, there is no trace of it (76), and its site is entirely membranous (*Mb*). It is similar in Neuropteran adults (142), but lacking in the pupa (141).

In the Lepidoptera (149), the Hymenoptera (169), and the Diptera (174 and 179) the pseudonotum is present in both segments and is easily distinguishable as the tergal plate behind the wing bases. In the mesothorax of these orders it carries the large phragma (150,

163, 170, 179, *Pph* or *Pph₂*) that projects posteriorly through the metathorax and almost shuts off the cavity of the thorax from that of the abdomen. In a Tipulid pupa (173) the mesopseudonotum (*PN*) is present as a large plate intervening between the two wing-bearing plates (*N₂* and *N₃*). It is interesting to note here that the halter is a wing-like structure (*W₂*).

The pseudonotum has been discussed at considerable length because the fact has apparently not been recognized by other authors that the postscutellum or pseudonotum is an independent plate in its origin and is, hence, not one of the divisions of the notum, as is the prescutum, scutum, or scutellum.

The notum (*N*) or wing-bearing plate of a meso- or metathoracic tergum is diagrammatically illustrated in figs. 1, 2, and 3. In its simplest form it is an undivided plate, convex dorsally. On its ventral surface (fig. 2) the anterior and posterior margins are thickened, forming the anterior notal ridge (*ANR*) and the posterior notal ridge (*PNR*). The latter is generally folded forward a short distance on the ventral surface, forming a free posterior reduplication (*Rd*) which often overlaps the sclerite following. The lateral margins of the notum are produced into two processes which carry two of the articular sclerites of the wing base. These lobes are the *anterior notal wing process* (*ANP*) and the *posterior notal wing process* (*PNP*). The posterior edge of the notum, formed by the posterior reduplication, usually appears as a marginal thickening which is continued outward on each side as a corrugated, cord-like thickening of the anal edge of the basal membrane of the wing. These thickenings may appropriately be called the *axillary cords* (*AxC*). They are important characters in determining the posterior limit of the notum. The anterior notal ridge bears the *anterior phragma* or *prephragma* (*Aph*).

This outline might be taken to represent the structure of the meso- or metatergum of primitive winged insects, for it is approximately that of nymphal and some pupal forms though these lack the notal wing processes. A pseudonotum is never present in nymphal stages and the prephragma is usually but little developed. The tergum of the nymph is illustrated in the Odonata (15), in the Mantidæ (31), in the Acridiidæ (56, 58) and in the Perlidæ (76). The same simplicity is exhibited by the pupal tergum of Coleoptera (122, 123, 126). In a Tipulid pupa (173), however, the pseudonotum is present in the mesothorax as a distinct plate (*PN₂*) between the two wing-bearing plates (*N₂* and *N₃*). As will be shown later, the notum of the adult is commonly divided more or less distinctly into several regions or even sclerites. But a study of nymphs and pupæ shows conclusively that these notal divisions are secondary characters in the growth of the individual. The tergum consists at

first of one plate—the notum, from the entire lateral margins of which the wings develop. Behind the notum is added, in the adult stage, the pseudonotum (postscutellum) as a distinct plate, while the so-called prescutum, scutum, and scutellum are formed as secondary divisions of the notum. These notal regions, moreover, are not homologous in all the orders. This can be proved by a study of the ventral surface of the notum, which presents certain fundamental characters common to nearly all insects. Two of these are the anterior and posterior notal ridges (fig. 2, *ANR, PNR*) already described; a third, and the most important one, is the V-shaped ridge (*V*), the *entodorsum* of Amans (1885), located on the posterior half of the notum, having its apex forward and the bases of its arms fused with the posterior ridge. A comparison of text figs. 1 and 2 will show that the three ventral ridges (*ANR, V, PNR*) form three transverse lines on the surface of the notum (*anr, v, pnr*).

These ridges and their surface lines are undoubtedly homologous structures in all insects. They mark off the area of the notum into four regions, as follows: (1) A narrow anterior marginal band in front of the line of the anterior ridge; (2) a large bilobed region situated between the line of the anterior ridge (*anr*) and that of the entodorsum (*v*) and carrying the notal wing processes (*ANP, PNP*); (3) a triangular space between the line of the entodorsum and that of the posterior notal ridge; and (4) a narrow posterior marginal band terminating laterally in the axillary cords (*AxC*) and forming the posterior free edge or reduplication of the notum.

This typical simplicity of structure is illustrated in the Orthoptera by *Blatella* (38, 40) and *Gryllus* (49, 50), and in the *Neuroptera* by *Corydalis* (142, 143). It will be observed that the pseudonotum (*PN*) is absent in the Orthoptera, but well developed in *Corydalis*.

These four regions of the Orthopteran notum are very suggestive of the four divisions of the tergum as ordinarily recognized, but a comparison with *Corydalis* (142) at once shows that the term "postscutellum" can not be applied to any part of the Orthopteran tergum, for the name belongs to the pseudonotum, which is absent in Orthoptera. Hence, all identifications of a "postscutellum" in Orthoptera, supposed to be homologous with that of the higher orders, are erroneous. A comparative study of the orders shows that the posterior line (*pnr*) is generally absent, that the notum is very commonly divided by lines or actual sutures into *three* subdivisions, and that these lines or sutures are *not* determined by the ventral ridges and do not bear the same relation to them in the different orders.

Thus we have the following premises: (1) The ventral ridges of the notum are constant in all the orders and are, hence, fundamental homologous structures; (2) three notal divisions are of general

occurrence but are not constant nor do they present the same relation to the ventral ridges in the different orders. From these facts it follows that the notal divisions are not necessarily homologous wherever they occur, though they may be so within limited series, and that they are simply secondary adaptations to some common demand upon the notum.

The above statements and conclusion can be verified by a study of the species illustrated on the plates. Since the subdivisions of the notum are best developed in the highest orders these will be described first. The ordinary names of *prescutum* (*psc*), *scutum* (*sct*), and *scutellum* (*scl*) will be used to designate the notal regions, but the reader must bear in mind that they are not used in the different orders in a homologous sense, and that the abbreviations on the figures do not designate parts necessarily homologous. The " postscutellum " will be called the pseudonotum (*PN*).

The notal divisions are probably as well shown in the mesothorax of a Tipulid fly as in any other insect. In *Holorusia grandis* (174, 175) the prescutum (*psc*) is a large plate with its posterior margin produced posteriorly in a large V-shaped angle, having no relation to the anterior notal ridge. The lateral posterior angles are produced into two small lobes (175, *u*) lying opposite the anterior angles of the wing bases. The scutum (*sct*) is a wide plate carrying the anterior notal wing processes (*ANP*). The scutellum (*scl*) consists of a median elevated shield and of a depressed area on each side. The posterior wing processes belong to the latter, though they are separated from it by a tongue of membrane. The ventral V ridge is present just as in the diagram (fig. 2), but it marks only the apex (*v*) of the scutellum, its lateral parts not showing on the surface. Thus the three divisions of the Tipulid notum are but slightly influenced by the ventral ridges. The pseudonotum (*PN*) is well developed, consisting of a median and two lateral plates, the latter articulated with the epimera (174, *Epm*). In a Tabanid (179, 180) the third division of the notum (*scl*) is distinct but the first (*psc*) and the second (*sct*) are not separated mesially. The lateral angles (*u*) of the prescutum, as in *Holorusia*, lie opposite the wing bases.

In the Hymenoptera similar divisions of the notum occur, as is well shown in the drawing (160) of *Parasiobla*, a Tenthredinid. An examination of the ventral surface reveals the V ridge present but situated entirely behind the suture between the scutum and scutellum. These two plates, furthermore, are easily separable along this suture and, hence, the latter can in no way be compared with the dividing line between the scutum and scutellum of the Orthoptera. In the example given (160) the prescutum (*psc*) is perfectly exposed, but it is more commonly hidden in the Hymenopteran mesothorax by the pronotum (169, N_1), which is attached to and overlaps

the anterior part of the mesothorax. The pseudonotum (PN) is also usually hidden on account of its projecting downward before the metathorax. It can easily be shown, however, by removing the mesotergum from the surrounding parts (163, 170).

The metanotum in both the Diptera and Hymenoptera is reduced in size and the subdivisions are not well marked (174, 169). The metapseudonotum is present in both orders but is generally very narrow in the Diptera. In the Hymenoptera it is usually a large plate (160, 169, PN_3) continuously fused on the sides with the metaepimera (Epm_3), though in some cases it is narrow and scarcely distinguishable from the metanotum (164).

In the Hymenoptera there occurs a fusion of the first abdominal segment with the metathorax. This fact has led to a great deal of discussion among entomologists and to the production of an immense amount of literature. Latreille (1821) first described the rear part of the apparent Hymenopteran thorax as being a part of the abdomen and named it the " segment médiaire." Newman later (1833) called it the " propodeon." Packard (1866), by a study of the development of *Bombus*, proved that the first abdominal segment is actually transferred to and becomes consolidated with the metathorax. A great many other writers have written a great many opinions about it and about the opinions of other writers, and Gosch (1881) has furnished a voluminous historical account of all the opinions of all these writers up to his time. To his Contribution to the History of Entomology (1881) the reader is referred if he is interested in this phase of the subject. If not, the examination of a few specimens of the insects concerned will probably suffice.

The abdomen of *Cimbex* (166) shows clearly enough that the first abdominal segment (164, IT) is much more closely attached to the thorax than to the rest of the abdomen. That the part in question is the first abdominal segment is proved by its spiracles ($I Sp$) and by the structure of the metathorax and of the rest of the abdomen. The metathorax of *Cimbex* (164) has, in addition to the attached part (IT), its full complement of sclerites. The notum (N) and pseudonotum (PN) are present dorsally and the episternum (Eps) and the epimerum (Epm) laterally. In the abdomen itself, if the first segment behind the one in question is counted as the first, there would be present only nine segments in all, and the absurdity would be forced upon us of referring the female gonapophyses to the seventh and eighth segments. Hence, arguing from either end, the conclusion would be that the *median segment* belongs to the abdomen. In *Parasiobla* (160) this segment could never be regarded as more than a slightly transposed part of the abdomen. However, in the higher forms, of which *Pepsis* (169) is a good representative, the median segment is so intimately grown into the metathorax that it certainly does not

appear to belong to the abdomen. Yet in the metathorax there is present the true metathoracic notum (N_3), and the pseudonotum (PN_3) identifiable by its fusion with the metathoracic pleura. Hence the large corrugated plate ($1T$) behind the pseudonotum has no place in the metathoracic anatomy, and its abdominal origin is proved by its spiracles ($1 Sp$). Thus a study of comparative anatomy proves conclusively that the " segment médiaire " is at least the first abdominal tergum which has been transferred to the thorax, and *Pepsis* indicates that the entire first abdominal segment is so transferred. If this is true, then the ventral part disappears as a distinct plate in the higher families.

In the Lepidoptera the mesonotum has much the same appearance as in the Diptera and Hymenoptera, but differs in details of structure. In the Cossidæ (149, 150) it consists of a large scutum (*sct*) and scutellum (*scl*) separated along the line of the ventral V-ridge, and of a very narrow prescutum (150, *psc*). The postscutellum (PN) is present, but normally (149) is almost hidden between the mesothorax and the metathorax. In the Sphingidæ (155, 156) the prescutum depends vertically from the anterior edge of the scutum (155) and carries the prephragma ($1ph$). The prescutum in *Phassus* is, therefore, much more nearly the equivalent of the anterior division of the notum in the diagram (fig. 1) than in either the Hymenoptera or the Diptera and, hence, is more similar to the Orthoptera (38) and Neuroptera (142). In the Diptera, it will be recalled, the prescutum is large and extends back to the bases of the wings. In the Hymenoptera it is remote from the wing bases. In *Phassus* (150) the scutum carries both the anterior and the posterior-wing processes of the notum, while in *Protoparce* (156) the posterior processes arise from the scutellum. This is due to the fact that here the lateral parts of the scutellum are not defined by the ventral V-ridge, but appear simply as depressed areas at the sides of the median elevated part of the scutellum as in *Holorusia* (175) and *Tabanus* (180). In this case the separation between the scutum and scutellum laterally is simply a matter of topography.

The metathorax of *Phassus* (149, 151) is larger and more like the mesothorax than is usual among the higher insects. The prescutum (*psc*) and the scutellum (*scl*) almost meet on the median line, thus separating the scutum into two lateral plates (*sct*). The posterior wing processes (PNP) arise in the angles between the scutellum and the scutum.

The scutellum in all the forms so far described carries the axillary cords of the wings (AxC) at its extremities. These cords, which are distinct in nearly all insects, are, hence, diagnostic of the location of the scutellum in Lepidoptera, Hymenoptera, and Diptera, defining its posterior margin, and consequently, the posterior edge of the

notum. The postscutellum (*PN*) lying behind them is always a plate more or less distinctly separated from the notum, but connected or continuously fused with the epimera.

In the Coleoptera there occur two special modifications of the metathoracic tergum which set the beetles apart in this respect from all the other orders. One of these characters is the forward extension of a median tongue of the scutellum toward the prescutum, cutting the scutum into separated lateral halves. The second character is the division of each lateral scutal plate again into two by lines formed by special transverse ventral ridges laterad of the apex of the **V**-ridge.

In a separate paper (1909) the author has shown that Audouin's interpretation of the coleopteran tergum is untenable, that, in order to make out his four transverse tergal sclerites, Audouin has represented certain parts as continuous which in nature are separate, and in other cases has made separations where none occur.

A Carabid, *Calosoma scrutator* (132, 133), presents a very simple arrangement of the metatergal subdivisions characteristic of the beetles. The prescutum (*psc*) consists of a large quadrate median part and of two narrow lateral arms widened terminally into the triangular anterior notal wing processes (*ANP*). The median part is separated by a membranous area (*mb*), the " toile " of Straus-Dürckheim (1828), from the anterior extension of the scutellum on the floor of the median notal groove (*G*). On its anterior ventral edge the prescutum carries the prephragma (*Aph*) mesially and the cup-shaped muscle apodemes (*MD*) laterally. The scutum (*sct, sct*) is divided into four plates by the median approximation of the prescutum and scutellum, and by the lines (132, *w*) formed by the special transverse ventral ridges (133, *w*). The posterior division on each side carries the posterior notal wing process (*P N P*). The scutellum (132, *scl*) presents a median enlargement carrying the tongue extending forward on the floor of the median notal groove (*G*) and determined by the entodorsum or ventral **V**-shaped ridge (133, *V*), while laterally it extends to the bases of the axillary cords (*A x C*) as a narrow marginal postscutal strip on each side, determined by the posterior notal ridge (*P N R*).

Behind the notum, and entirely separated from it by a flexible suture, is the pseudonotum (postscutellum) (*PN*), carrying the postphragma (*Pph*) and articulating at its extremities (*i*) with the epimera.

Dytiscus dauricus (136, 137), is very similar in its metatergal structure to *Calosoma* (132, 133). The lateral arms of the scutellum, however, are larger and, in addition to carrying the axillary cards, they support the combined bases (*r*) of the anal veins of the wing. The ventral ridges (137, *V, w*) are much larger than in *Calosoma*.

The higher families of beetles, illustrated by *Hydrophilus triangularis* (134), *Melolontha vulgaris* (135, 138), and *Cyllene robiniæ* (140), have a prescutum somewhat different in appearance from that of *Calosoma* and *Dytiscus*. In *Hydrophilus* (134) and *Cyllene* (140) its median part (*psc*) is narrow and arched forward, and the membranous area (*mb*) back of it is extended transversely. The scutellum (*scl*) appears to have a long median tongue (*G*) by itself entirely separating the scutum into lateral halves. The anterior scutal subdivisions, in front of the transverse dividing lines (*w*), which are incomplete in *Hydrophilus*, are reduced to turgid antero-lateral corner lobes. The lateral extensions of the scutellum in each of these genera fuse laterally with the parts in front of them, so that the axillary cords (*AxC*) appear to be attached to the margins of the scutum (134, 140). *Melolontha vulgaris* departs still more widely from the *Calosoma-Dytiscus* type. The median part of the prescutum is represented entirely by the very large prephragma (135, 138, *Aph*), which is supported by the lateral parts of the prescutum and separated from the scutum and scutellum by an extensive membranous area (*mb*). The scutum (135, *sct, sct*) is divided, as in the other genera, into lateral halves by a median tongue of the scutellum (*scl*) on the floor of the median notal groove (*G*), but the transverse ridges (138 *w*) are coincident with the anterior scutal margins and do not subdivide the scutal plates. The scutellum (*scl*) is not defined laterally, but two triangular postero-lateral divisions of the scutum, the " scapulaire posterieure " of Straus-Durckheim (1828) carry the posterior notal processes (*PNP*) and the axillary cords.

The pseudonotum is well developed in all of these genera (134, 135, 140, *PN*) and carries the postphragma (*Pph*). The latter is specially large and of complicated structure in Melolontha (139, *Pph*).

The mesonotum of beetles is apparently constructed on the same plan as the metanotum. A pseudonotum is lacking. In *Calosoma* (127) and *Dytiscus* (128) the prominent shield-shaped area (*scl*) corresponds with the median part of the scutellum of the metanotum, lateral arms extending from it which carry the axillary cords (*AxC*). Laterad of the median shield are the separated halves of the scutum (*sct*) carrying the posterior wing processes of the notum (*PNP*). In front of it is a large complex prescutal part (*psc*) carrying the anterior phragma (*Aph*) and laterally the anterior notal wing processes (*ANP*). Two little plates (*q*) lie between the mesonotum and the metanotum. These may be rudiments of a mesopseudonotum, but they are more closely connected with the metanotum than with the mesonotum. On the ventral surface of the mesonotum (131) a V-shaped ridge (*V*) is present similar to that of the metanotum. In most other beetles the parts of the mesonotum are so blended that any plan of structure closely corresponding with that of the metanotum

can not be made out. Yet a progressive modification from the *Calosoma-Dytiscus* type can be traced through *Hydrophilus* (125), *Cyllene* (129), and *Dendroctonus* (124).

It is thus clear that the same fundamental structure of the notum obtains throughout the Coleoptera, the Lepidoptera, the Hymenoptera, and the Diptera, but that the notal subdivisions are not necessarily determined by it.

In the Neuroptera a tergum of diagrammatic simplicity is found. In *Corydalis* (142, 143) the scutum (*sct*) and scutellum (*scl*) are separated along the line (142 *r*) of the ventral V ridge (143 *V*). Anteriorly and posteriorly are narrow marginal areas defined by the anterior and posterior notal ridges (*ANR, PNR*). The first of these might be called the prescutum, but the second is simply the posterior notal reduplication (*Rd*) and does not correspond with the postscutellum of higher orders, for this is the pseudonotum, which is well developed in *Corydalis* (142, *PN*).

In the Euplexoptera the metanotum of *Spongiphora* (96) consists of an undivided plate carrying both the anterior and the posterior wing process (*ANP, PNP*), while articulated near the middle of its posterior margin are two long arms (*f*) bearing the axillary cords (*AxC*). In the mesonotum (90) there is a large anterior triangular part carrying the anterior notal wing processes (*ANP*) and two lateral divisions carrying the posterior wing processes (*PNP*). It is evident, however, that neither tergum of *Spongiphora* is normal, for neither presents any trace of the V-shaped ridge, and the general shape is peculiar to the order. A ventral view of the mesonotum (92) shows that the two apparent divisions are due merely to elevations and depressions of the surface.

In the Belostomidæ of the Hemiptera the mesonotum presents a wide, strongly declivous prescutal area carrying the prephragma and limited posteriorly by a definite transverse line. Back of it are two transverse grooves separating three other divisions. The last is simply the long posterior reduplication which in the Hemiptera overlaps the mesonotum. There is but a faint trace of the V ridge in *Benacus* and it does not influence the notal subdivision. The metanotum is also much modified, carrying an unusually large prephragma and lacking the V ridge. In *Benacus* (87) it is clear that both of the notal wing processes (*ANP* and *PNP*) arise from the scutum. A very narrow pseudonotum (88 *PN*) is present, connecting with the epimera laterally. The first abdominal tergum (*IT*) is also much modified and closely connected with the pseudonotum. It can be identified by its lateral spiracles (*I Sp.*).

In the Plecoptera, as illustrated by *Pteronarcys californica* (75), the indistinct regions of the notum are due entirely to the topography. The anterior and posterior notal regions are weakly developed while

there are but indistinct traces of the **V** ridge. The apex of the latter is entirely lacking, so that the area corresponding with the median part of the scutellum of the Diptera or Lepidoptera here appears as a median posterior lobe of the scutal region. This is very suggestive of the Acridiidæ. The pseudonotum (*PN*) is a large plate equally developed in both meso- and metathorax of adults, though conspicuously absent in the nymphs.

The simple type of tergum occurring in the Orthoptera has already been described and is illustrated by *Blatella* (38, 40) and by *Gryllus* (49, 50). Both of these forms present a meso- and metanotum of almost typical diagrammatic form. The pseudonotum is lacking in all Orthoptera (see p. 558), and the divisions of the notum are only such as are indicated by the ventral ridges. All other regional diversifications are purely topographical.

In a winged Locustid, *Microcentrum laurifolium*, neither the mesonotum (39) nor the metanotum (41) shows any subdivisions except such as are marked out by elevations and depressions. Only rudiments of the **V** ridge occur (*V*). A small-winged adult Locustid, such as *Anabrus simplex*, has the notum (42) of almost nymphal simplicity.

In the Acridiidæ the meso- and metanotum are almost identical with each other. An under view of the mesonotum of *Hippiscus phœnicopterus* (54) shows considerable departure from the other Orthopteran families. The **V**-shaped ridge (*V*) is low and flat and not ridge-like. The posterior notal ridge (*PNR*) is, however, well developed and is almost phragma-like. Diverging forward and outward from its middle are two high thin ridges (*s, s*) which do not occur in the other families. The posterior reduplication (*Rd*) forms a marginal thickening carrying laterally the axillary cords (*AxC*). On the dorsal surface (53) five regions are distinguishable. The first is a narrow median anterior area separated by a suture-like line (*anr*) formed by the anterior notal ridge. The second occupies most of the back and consists of two large anterior lateral lobes and of a smaller median posterior lobe. It bears the anterior notal wing processes (*ANP*). The third and fourth divisions lie laterad of the median posterior lobe and are demarked by the lines of the posterior notal ridge (*pnr*) and the ridges (*s, s*) diverging from the latter. Each is a transverse, elongate oval area tapering mesially, laterally bearing the posterior wing process (*PNP*). The fifth region, marked in front by the line of the posterior notal ridge (*pnr*), is the thickened posterior reduplication carrying the axillary cords (*AxC*).

This description, as far as the writer can see, expresses the facts concerning the Acridiid mesonotum. Yet, various entomologists, by a vigorous exercise of the imagination, have made out four transverse divisions, thus compelling the locust to fall in line with the beetles,

moths, and flies. It may be very gratifying to imagine that it does, but, when it clearly does not, what is gained by imagining that it is as it is not?

The pronotum of nearly all the Orthoptera is a simple plate, but when we come to the Acridiidæ we find it divided into four very distinct transverse parts. In fact the pronotum of *Melanoplus* affords the most popular illustration of the quadruple construction of the insect back. But here (51) it must be observed that the notum not only covers the dorsum, but has usurped the territory of the pleurites (Eps, Epm) which it has all but crowded out. An examination of the inner surface (52) shows that the third external groove (z) marks an internal ridge against which the inner lamina of the long posterior reduplication (Rd) ends. The middle groove (y) marks a large internal notal ridge (NR) exactly similar to the internal pleural ridge (PR) of any normal thoracic pleurum such as that of the mesothorax of *Anabrus* (44) or of *Dissosteira* (71). There is present even a notal apodemal arm (NA) representative of the normal pleural arm (PA). The coxa is carried by an apparently notal coxal process ($NCxP$) in every way similar to the ordinary pleural coxal process (CxP), though this may really belong to the rudimentary pleurum. Finally, the leg muscles are disposed upon the notal surfaces at each side of the middle notal ridge just as they are upon the episternum and epimerum of a normal pleurum. Hence, it is clear that we have here simply a secondary modification of the notum due to its assumption of the duties of the pleural plates which it has crowded out. It is really most illogical that the pronotum of *Melanoplus* should be offered as a typical example of a thoracic tergum, for a tergum doing duty as both notum and pleura is, on the face of it, not typical. Yet in almost any discussion of insect anatomy the prescutum, scutum, scutellum, and postscutellum will be found principally illustrated by the pronotum of an Acridiid.

In the Odonata the pronotum of both nymphal and adult forms is divided into three transverse lobes by two transverse grooves. They are best developed in adults (5, 7, 9, 13), but are well marked also in the nymphs (8, 12). An unusual feature in some is the extension downward from the third lobe of a postepimeral strip (a) of the notum. The meso- and metanotum are sufficiently shown by the illustration of *Pachydiplax longipennis* (17). The two are similar and each is subdivided somewhat as in the Acridiidæ and the Perlidæ. The wing articulation shows few of the characters common to all the other orders except the Ephemerida, and the wing muscles are nearly all attached to the base of the wing itself, a condition peculiar to the order. The pseudonotum (PN) is well developed in each segment. In the mesothorax (PN_2) it is exceptionally large and is divided by ventral ridges into a median and two lateral lobes.

The Ephemerid mesotergum and metatergum are sufficiently shown in the drawings of *Hexagenia bilineata* (4, 3). Each presents simply a confusion of elevations and depressions showing little similarity to any other order. A posterior median lobe, however, suggests the similarly situated lobe in Odonata (17), Acridiidæ (53), and Perlidæ (75), and also the median part of the scutellum of Lepidoptera (150), of Hymenoptera (161), and of Diptera (175). It is also comparable with the median shield-shaped area of the mesothorax of Coleoptera (127, 128). A pseudonotum (3, *PN*) is present in each segment, but is hidden from above by a posterior membranous fold margined by the axillary cords (4, *Ax C*).

This review of the notal structure in the different orders will show that the diagrammatic conception of the notum illustrated in fig. 2 is really the fundamental notal structure that prevails in all the principal orders except the Ephemerida and the Odonata. It is evident that the three ventral ridges—the anterior, the **V**-shaped, and the posterior—are constant characters and that the regions they mark off can be regarded as homologous in all the orders. But such subdivisions are not the ones usually apparent on the surface, and the latter, though generally the same within an order, vary so much in different orders that they can not be regarded as homologous structures except within limited series.

Three factors contribute to the formation of the notal subdivisions as follows: (1) Topography, as elevations and depressions of the surface forming more or less distinct regions, some of which appear variously modified throughout nearly the entire insect series; (2) ventral ridges, three of which are constant characters and, hence, to be regarded as homologous in the different orders; and (3) depressed suture-like lines and actual sutures, variable and not the same in different orders and, hence, not necessarily defining homologous sclerites.

Therefore, it may be concluded from a study of development and comparative anatomy that any scheme of thoracic structure in insects is untenable which postulates four primitive transverse plates in the tergum. Much less is there any evidence that the definitive tergum is composed of the united terga of two or four primitive metameres.

This conclusion is opposed to that of Berlese (1906), who finds in the thoracic terga of all orders four exactly corresponding parts, the " acrotergite," the " protergite," the " mesotergite," and the "metatergite." An examination of his colored diagrams (1906, Plate 4) will show, however, that in order to carry out his scheme Berlese has in many cases drawn purely arbitrary lines across the notum. Moreover, he has disposed of the pseudonotum by making it the " acrotergite " of the segment following the one to which it is attached. Thus he equates the mesopseudonotum and its phragma in *Sphinx* with the metaprephragma of *Acridium*. The pseudonotum

(postscutellum) of *Hydrophilus* he evidently calls the acrotergite of the first abdominal segment and equates it with the anterior subdivision of the first abdominal tergum of *Acridium*. He appears to disregard entirely the intimate connections of the pseudonotum with the epimeral plates belonging to the segment of the preceding notum and its attachment to the preceding notum itself.
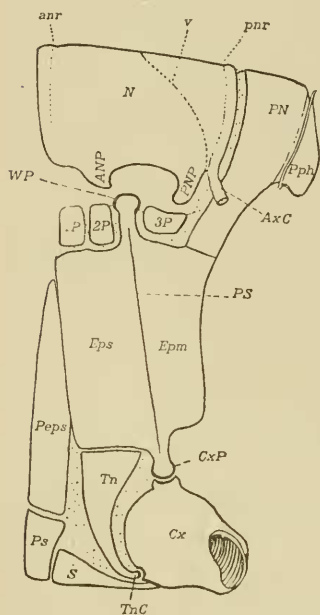
2. The Pleurum and Coxa.

The key to the structure of the pleurum is the *pleural suture*. To determine this proceed as follows: Find the pleural process that supports the base of the wing; locate the pleural condyle to which the coxa is articulated; observe the impressed line that extends between these two articular knobs. This is the pleural suture. The *episternum* lies in front of it, the *epimerum* behind it. In wingless forms the pleural suture must be determined by the coxal articulation alone. The suture may be horizontal, in which case the contiguous plates necessarily lie above and below it. Very rarely it is lacking, though such is conspicuously the case in the metathorax of most of the Hymenoptera. Internally the pleural suture forms a large ridge along its entire length, and this *pleural ridge* is of great assistance in determining the pleural suture when the latter is obscure or when there are other similar sutures externally.

The plan of any wing-bearing thoracic pleurum is illustrated diagrammatically by figs. 3 and 4. Externally (fig. 3) is seen the *pleural suture* (*PS*) extending upward to an arm bearing the wing, the *pleural wing process* (WP) and ventrally to a condyle bearing the coxa,

the *pleural coxal process* (*CxP*). Internally (fig. 4) is seen the heavy *pleural ridge* or *entopleurum* (*PR*), a large ridge-like apodeme lying along the line of the pleural suture, terminating in

Fig. 3.—Diagrammatic lateral view of any complete wing-bearing segment, external; *ANP*, anterior notal wing process; *anr*, line of anterior ventral notal ridge; *AxC*, axillary cord; *Cx*, coxa; *CxP*, coxal process of pleurum; *Epm*, epimerum; *Eps*, episternum; *N*, notum; *1P*, *2P*, episternal parapltera or preparaptera; *3P*, epimeral parapterum or postparapterum; *Peps*, preepisternum; *PN*, pseudonotum or postnotum; *PNP*, posterior notal wing process; *pnr*, line of posterior ventral ridge; *Pph*, postphragma; *PS*, pleural suture; *Ps*, presternum; *S*, sternum; *Tn*, trochantin; *TnC*, trochantinal coxal condyle; *v*, line of ventral V-shaped notal ridge; *WP*, pleural wing process.

the wing process (*WP*) above and the coxal process (*CxP*) below, and bearing a *pleural arm* (*PA*) projecting inward and downward.

Anterior and posterior to the pleural suture, or ventral and dorsal to it when the suture is horizontal, are the episternum (*Eps*) and the epimerum (*Epm*), respectively. These are the two principal plates of the pleurum, and, by their contiguous and infolded edges, they form the pleural suture externally and the pleural ridge internally. The epimerum is nearly always connected, either by an articulation or by fusion, with the lateral part of the pseudonotum (text fig. 3, *PN*).

A study of nymphal pleura (*Melanoplus*, 55, 56) shows clearly that the episternum and epimerum are merely subdivisions of one original plate to which the leg is articulated. Before the wings are developed, the pleural suture does not extend to the dorsal edge of the plate. On the inner surface (55) the pleural ridge (*PR*) is well developed ventrally to strengthen the plate in its function as a supporter of the leg, and the pleural suture is merely the external mark of the formation of the ridge. All the upper pleural structures, the wing process, and the parapteral plates are developed only when the wing becomes functional. In forms with rudimentary wings in the adult stage, such as *Anabrus simplex* (43, 44), these parts are present, but reduced in size. A study of the Chilopoda also appears to indicate that the episternum and epimerum originate as subdivisions of one plate. The lower chilopods, such as *Mecistocephalus* (20), present a number of plates on the side of the segment, one of which (*Pl*) lies immediately over the coxa. The series running through *Scolopocryptops* (21), *Lithobius* (22), and *Cermatia* (23) shows a disappearance of all the other plates, while this one in *Cermatia* (23, *Pl*) becomes divided by a median thickening into two parts resembling the episternum and epimerum of a nymphal orthopteran (56).
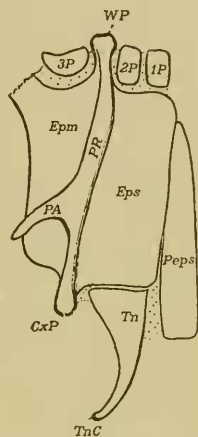

Fig. 4.—DIAGRAMMATIC VIEW OF INNER SURFACE OF THE PLEURUM OF ANY COMPLETE WING-BEARING SEGMENT; *CxP*, COXAL PROCESS OF PLEURUM; *Epm*, EPIMERUM; *Eps*, EPISTERNUM; *1P*, *2P*, EPISTERNAL PARAPTERA OR PREPARAPTERA; *3P*, EPIMERAL PARAPTERUM OR POSTPARAPTERUM; *PA*, PLEURAL ARM; *Peps*, PREEPISTERNUM; *PR*, PLEURAL RIDGE (ENTOPLEURUM); *Tn*, TROCHANTIN; *TnC*, TROCHANTINAL COXAL CONDYLE; *WP*, WING PROCESS OF PLEURUM.

Associated with the base of the wing are several small plates lying before and behind the wing process (*WP*). These are the paraptera (*P*). There are never more than two in front of the wing process and they may be called the *episternal paraptera* or the *preparaptera* (*1 P, 2 P*). There is generally only one *epimeral parapterum* or *postparapterum* (*3 P*), though some Perlidæ present a second. Voss

(1905) calls the preparaptera the "episternalgelenkplatten," and the postparaptera the "epimeralgelenkplatten." These are excellent descriptive terms but too cumbrous for translation into English or Latin equivalents, and it is well to preserve the name "parapterum" of Audouin.

Either one or both of the episternal paraptera are connected with the head of the costal vein of the wing by strong membrane, and upon their inner surfaces are inserted the strong pronator wing muscles by whose contraction the wing is turned forward upon the pleural wing process and its costal or front edge depressed. In the higher insects there is frequently only one preparapterum present and it very commonly carries a large muscle disc on its inner surface which forms the insertion of the pronator muscle. This whole structure is called the "appareil de pronation" by Amans (1885). The muscle disc may be specifically designated as the *pronator disc* (*PD*). This is not shown in the diagram, for it occurs mostly in the higher orders. As examples of it see illustrations of the Euplexopteran metathorax (98, 100, *PD*), the Coleopteran mesothorax (101, 129), the Coleopteran metathorax (110–121), and the Hymenopteran mesothorax (165). In the Lepidoptera (154) the pronator disc (*PD*) is carried by the upper edge of the episternum, but the parapterum (*P*) is also fused with the latter.

In the Coleoptera there is only one preparapterum present. In the mesothorax it is usually represented by a small inconspicuous plate or rod connected with the head of the elytrum and lying before the wing process (102, 103, 105, 107, 108, *P*), only in rare cases does it bear a pronator disc (101, 129, *PD*). In the metathorax, on the other hand, the disc is always large and prominent (110–121, *PD*). In *Calosoma scrutator* (Carabidæ) the parapterum and its disc (110, 113, *P* and *PD*) are loosely articulated to the front of the wing process (*WP*). In *Dytiscus dauricus* (Dytiscidæ) the parapterum (114, 115, *P*) is closely articulated to the front of the wing process. In *Hydrophilus triangularis* (Hydrophilidæ) the parapterum (*P*) is fused with the base of the wing process (111, 112) and to the anterior edge of a subdivision (*eps*) of the episternum (*Eps*). The line of fusion, however, is easily seen. The same condition is found in *Melolontha vulgaris* (Scarabæidæ) where the base of the parapterum (121, *P*) and the episternal subdivision (*eps*) are closely united. Finally, in such forms as *Cyllene robiniæ* (Cerambycidæ) and *Dendroctonus valens* (Scolytidæ) these two parts (116, 118, *P* and *eps*) are so entirely fused that the line of union is gone. Thus in the higher beetles the appearance of two wing processes (118, *P* and *WP*), carried by the episternum and epimerum, respectively, is produced. The series of forms just described, however, shows conclusively that this condition is secondarily brought about through

the fusion of the base of the parapterum with the front of the epi-sternum. The same thing occurs less conspicuously in several other orders. In the Neuroptera, *Corydalis cornuta* (147) has the single preparapterum (*P*) fused with the upper end of the epi-sternum (*Eps*), thus giving the appearance of there being two wing processes. The same thing is true of the Trichoptera as shown by *Neuronia ocellifera* (146, 148). Even in the Lepidoptera the parap-terum (*P*) of *Phassus triangularis* (153) is not really separated from the episternum (*Eps*), and forms a large lobe in front of the wing process (*WP*). Here the base of the wing process sends a long arm (153, 154, *tg.*1) forward and upward to support the tegular plate of the notum (150 *tg*). This, however, is peculiar to the Lepidoptera. It will be observed that in all cases the true wing process can be identified by the fact that it is derived from both the episternum and the epimerum, while the process formed of the parapterum is connected only with the episternum.

The postparapterum or epimeral parapterum (text figs. 3, 4, *3 P*) is of less importance than the preparaptera. It is a small plate of irregular and variable shape lying in the membrane of the base of the wing behind the wing process of the pleurum. It is often lack-ing, being never present in beetles. It is illustrated in the Corro-dentia (82, *3 P*), the Trichoptera (146, 148, *3 P*), the Lepidoptera (149, 153, 154, *3 P*), and the Diptera (174, 176, 179, *3 P*).

In a few of the lower orders a plate frequently occurs before the episternum (text figs. 3, 4, *Peps*). This is the sclerite which Verhoeff (1903) calls the " katopleure " in the Euplexoptera (Dermaptera) and it is well shown in this order by *Spongiphora* (94, *Peps*). But the plate which Verhoeff so designates in the Blattidæ (32, 35, *eps*) would seem to be only a subdivision of the episternum (*Eps*) not compara-ble with the sclerite in Euplexoptera. The writer formerly (1908) adopted the name " katopleure " for this sclerite, but here substitutes the more appropriate term *preepisternum* suggested by Dr. A. D. Hopkins. The preepisternum falls in line with the presternal ele-ment (*Ps*) of the ventral parts (text fig. 3, *Peps* and *Ps*).

The preepisternum is illustrated in the prothorax (26, *Peps*) and the mesothorax (27, 28) of *Spodromantis guttata* (Mantidæ), in the mesothorax (35) of *Ischnoptera hyalina* (Blattidæ), in the meso-thorax (43, 44) of *Anabrus simplex* (Locustidæ), in the mesothorax (47) of *Gryllus pennsylvanicus* (Gryllidæ), in the nymphal meso- and metathorax (55, 56) of *Melanoplus*, in the adult (57) of *Hippis-cus phœnicopterus*, and the adult (70, 71) of *Dissosteira carolina* (Acridiidæ), and finally in the mesothorax (94) of *Spongiphora apicidentata* (Forficulidæ). It does not appear to be present in the higher orders, though anterior subdivisions of the episternum occur, especially in the mesothorax of Coleoptera (102, 107, 109). Such

subdivisions, however, are never detached plates, but are simply parts of the episterna equivalent to the superior subdivisions (102, 105, 109, *epm*) of the mesothoracic epimera (*Epm*), and to the subdivisions (111–121, *epm*) of the metathoracic epimera. The writer formerly (1908) wrongly identified this last plate with the postparapterum, a sclerite which is absent in the Coleoptera.

An important sclerite in the pleurum of insects and undoubtedly a primitive plate in the thorax is the *trochantin* (*Tn*). This is a plate lying in front of the coxa (text fig. 3, *Tn*), connected above with the lower edge of the episternum (*Eps*) and articulating below by a small condyle (*TnC*) with the ventral rim of the coxa. Hence, when the trochantin is present, the coxa turns on a hinge line between the coxal condyle of the pluerum (*CxP*) and the coxal condyle of the trochantin (*TnC*). The trochantin is well shown in the Mantidæ (26, 27, 28) and in the Blattidæ (29, 32, 35). In the latter family it is divided into two parts (*Tn* and *tn*). The smaller part (*tn*) is what Comstock and Kochi (1902) call the "second antecoxal piece," but this part carries the coxal articulation and is, therefore, certainly the principal part of the trochantin.

The trochantin is well developed in the Locustidæ (43) and the Gryllidæ (46, 47). It is small or rudimentary in the Acridiidæ (51, 56). In the Plecoptera its upper end is fused with the episternum in the meso- and metathorax (78, 79). In the prothorax it inserts itself entirely between the episternum and epimerum and the coxa (72, 73, *Tn*), thus separating the latter from its true pleural coxal process. By way of reparation to the coxa, however, the trochantin develops a dorsal coxal condyle (72, 73, 74, *Tn CxP*) in addition to its usual ventral coxal condyle (*TnC*). It even goes further and actually presents an internal trochantinal ridge (74, *TnR*) simulating the true pleural ridge (74, *PR*). This is, of course, a highly specialized condition.

The trochantin occurs in typical form in the Euplexoptera (91, 94, 98, 100). It is present in the prothorax of *Benacus* (Hemiptera) though concealed by the overlapping pleurum (83 *Tn*). In most of the Coleoptera it is a very small plate in the pro- and mesothorax (99, 104, *Tn*) concealed at the upper end of the coxa within the coxal cavity. In the Silphidæ (106) and Buprestidæ (109), however, it is an exposed plate (*Tn*) occupying the normal position between the episternum (*Eps*) and the coxa (*Cx*). It is absent in the Coleopteran metathorax. In the Neuroptera (147) and Trichoptera (146, 148) it is a large plate. In the Lepidoptera (149, 153, 154, 158, 159) it is partially or entirely fused with the episternum, and is not very distinct from an arm of the sternum (*S*) in front of it. Its ventral coxal articulation is weak or absent. In the Hymenoptera and Diptera the trochantin is either absent or is indistinguishably consolidated with the sternum.

If there is any close relation between the plates of a chilopod segment and those of an insect thoracic segment a study of the former would indicate that the trochantin is really a sternal element. In *Mecistocephalus* (20) the lower half of the coxa is surrounded by a large bilobed lateral subdivision (*Tn*) of the sternum (*S*). In *Scolopocryptops* (21) this plate (*Tn*) is atrophied behind the coxa but articulates with the latter by a special condyle. *Lithobius* (22) shows a similar condition, but here the lower end of the trochantin-like plate (*Tn*) is overlapped by what is the median division of the sternum in *Mecistocephalus*. Verhoeff (1903) calls this plate in the Chilopoda the " trochantin." It is absent in *Cermatia* (23). Börner (1903) regards the trochantin as a " sternales schnürstück " and not as a pleural plate.

Audouin (1824) first specifically applied the term " trochantin " to the plate in *Buprestis gigas* which intervenes between the " epimerum " and the coxa. It happens, however, that in *Buprestis* the episternum presents a number of subdivisions, and Audouin must have included the posterior of these with the epimerum, thus referring to the trochantin as articulating the " epimerum " with the coxa. (See *Buprestis arulenta*, 109, *Tn*.) It will be evident, however, that the plate called " trochantin " by Audouin in *Buprestis* is the plate which in this paper is identified as such in all the orders where it occurs.

Verhoeff (1903) designates as the trochantin the sclerite lying before the coxa and carrying its ventral articulation.

Comstock and Kochi (1902), as already stated, define as the " trochantin," in the Blattidae, a plate which is only a part of the entire trochantin, since it does not carry the ventral coxal articulation. The subdivision of the trochantin bearing the latter is the " second antecoxal piece " of Comstock and Kochi.

Comstock and Kellogg (1902) describe the trochantin as a plate " considered to be an appendage of the coxa between the coxa and the antecoxal piece."

Packard (1896) defines the trochantin as a posterior division of the coxa attached to the epimerum. He refers to the " coxa meron " of Walton (1900) in the Neuroptera, Trichoptera, and Lepidoptera, which is not the trochantin at all, but a subdivision of the epimerum fused with the hind edge of the coxa.

The writer agrees with Verhoeff (1903) in his conception of the trochantin, because this appears to agree with Audouin's original use of the term.

Sometimes small additional plates occur between the trochantin and the coxa. These may be called *accessory trochantinal* or *accessory coxal sclerites*, according as they are associated more with the trochantin or the coxa (91, 94, 98, 100, *Tna*, *Cxa*).

The coxa (*Cx*) is too familiar to need any special description. As already shown (text fig. 3) it is articulated dorsally to the coxal process of the pleurum (*CxP*) and ventrally to the coxal process of the trochantin (*TnC*). The latter may be a sternal element, but it is only in the nymphs of Odonata that the coxa is articulated directly to the sternum (11, 16, *d*). In the Hemiptera and the Coleoptera the upper ends of the coxae are usually hidden by the overlapping pleurites, but even in such cases the coxa will usually be found articulated to a hidden coxal process of the pleural ridge.

The coxa has often been conceived of as a double structure representing elements corresponding with the episternum and the epimerum. The basis for this idea is furnished chiefly by the Neuroptera, Trichoptera, and Lepidoptera. Here the meso- and metathoracic coxae of adults are composed distinctly of an anterior and a posterior segment (147, 148, 149, 153, *Cx* and *epm*). Banks (1893) regarded the coxa as derived from two segments, the leg being the appendage of the first in each pair and the coxal spur of *Machilis* representing the appendage of the second segment. Walton (1900) described the two coxal segments as the "coxa genuina" and the "coxa meron." Packard (1898) called the posterior division the "trochantin."

A study of larval and pupal forms in the Neuroptera and Trichoptera shows that this double structure of the coxa is a purely secondary condition. In the larva of *Corydalis cornuta* (144) the meso- and metacoxae are simple structures like the prothoracic coxa. The epimerum is divided by an oblique groove into an upper plate (*Epm*) and a lower plate (*epm*). In the pupa (145) the lower epimeral subdivision (*epm*) has extended downward behind the coxa (*Cx*) and is partially joined to it. In the adult (147) the lower epimeral plate (*epm*) is entirely fused upon the rear side of the coxa (*Cx*) and, moreover, is separated by a membraneous area from the upper epimeral plate (*Epm*). This would appear effectively to dispose of the bisegmental notion of the structure of the coxa in this order. The same developmental process can be shown to take place in the Trichoptera. A pupa of *Neuronia ocellifera* (146) has a long extension (*epm*) of the epimerum (*Epm*) united to the posterior edge of the coxa (*Cx*). In the adult (148) this is separated from the upper part of the epimerum and appears as a posterior segment (*epm*) of the coxa (*Cx*). Probably the same condition could be shown in a freshly pupated Lepidopteran.

Hence, it may be concluded that the double structure of the coxa in these orders is purely a secondary modification and can in no way be used as evidence of a bisegmental origin of the thoracic segments.

3. THE STERNUM.

The writer has not been able to make an extensive study of the sternum. Comstock and Kochi (1902) have recognized three trans-

verse divisions of the chitinous ventral parts and designated them the *presternum, sternum,* and *sternellum.* These three parts are shown in the mesothorax of a cockroach (32, *Ps, S,* and *Sl*). The presternum, however, is more commonly present as two small plates lying near the anterior angles of the sternum, the " Vorplatten " of German entomologists. Such plates are present in the prothorax of the Odonata, in a few species of which they unite across the median line in front of the sternum (11, *Ps*), but more usually form two lateral plates separated from the median presternal part (6, 7, 10, *Ps*). In most cases they are, furthermore, fused with the episterna (11, 12, 13, *Ps* and *Eps*). The presternal plates are shown also in the Locustidæ (43), the Gryllidæ (46, 47), the Perlidæ (80), the Corrodentia (82), and in the Forficulidæ (91, 94, 98).

From the inner sternal surface there projects dorsally the *entosternum,* consisting most commonly of two chitinous arms, the *furca* (text fig. 6, *Fc*). In some cases the base of the entosternum appears to mark the line between the sternum and sternellum. It is shown to be an invagination by the pit or pair of pits which often marks its location externally (10, 11, *e*). Sometimes the sternum bears also a long median posterior apodemal arm. This is shown in the prothorax of a moth (152, *l*).

V. THE WING ARTICULATION.

The wings are articulated to the body by a simple arrangement of axillary sclerites, two of which hinge upon the anterior and posterior wing processes of the notum while one rests upon the wing process of the pleurum. This is true of all the orders except the Ephemerida and the Odonata. These will, therefore, be omitted from the present discussion and described later under the special descriptions of the orders.

Text figs. 1 and 5 sufficiently represent the *axillary sclerites (1 Ax, 2 Ax, 3 Ax, 4 Ax*) in their relations to one another, to the notal wing processes, and to the bases of the veins, while fig. 6 shows the articulation with the pleurum. The fourth axillary is usually absent, but since it occurs in the Orthoptera and the Hymenoptera and since, when it is present, the arrangement is more symmetrical, it is included in the diagrams. When it is absent the third axillary articulates directly with the posterior notal wing process. Several other less definite plates usually occur in the central part of the wing base associated with the median, cubital, and first anal veins. These plates, however, are too variable to be given distinctive names and will be referred to in general as the *median plates.*

The membrane of the wing·base may be named the *axillary membrane (AxM).* On its anterior margin opposite the base of the costal vein is a small, hairy, semichitinous pad *(Tg).* This, in

the higher insects, develops into a scale-like lobe overlapping the base of the wing. In such cases it is known as the *tegula*, but this name is used in the present paper to designate both the well-developed tegula of the Lepidoptera, Hymenoptera, and Diptera, and its pad-
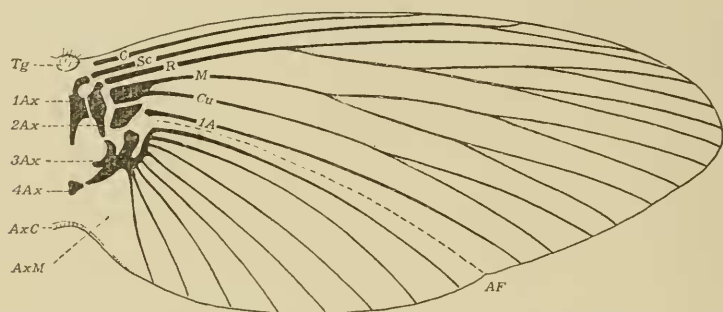

FIG. 5.—DIAGRAM OF A GENERALIZED WING AND ITS ARTICULAR SCLERITES OR AXILLARIES; *1 A*, FIRST ANAL VEIN; *1F*, FIRST ANAL FOLD; *1 Ax*, *2 Ax*, *3 Ax*, *4 Ax*, FIRST, SECOND, THIRD, AND FOURTH AXILLARIES; *AxC*, AXILLARY CORD; *AxM*, AXILLARY MEMBRANE; *C*, COSTA; *Cu*, CUBITUS; *M*, MEDIA; *R*, RADIUS; *Sc*, SUBCOSTA; *Tg*, TEGULA.

like representative in other orders. The posterior free margin of the axillary membrane is thickened in such a way that it has the appearance of being a corrugated cord attached to the posterior angle of the notum. It is here called the *axillary cord* (*AxC*).
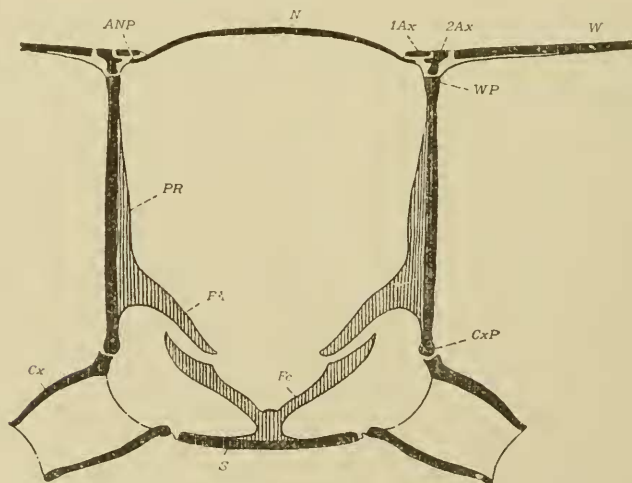

FIG. 6.—DIAGRAMMATIC CROSS SECTION OF A WING-BEARING SEGMENT; *ANP*, ANTERIOR NOTAL WING PROCESS; *1 Ax*, FIRST AXILLARY; *2 Ax*, SECOND AXILLARY; *Cx*, COXA; *CxP*, COXAL PROCESS OF PLEURUM; *Fc*, FURCA (ENTOSTERNUM); *N*, NOTUM; *PA*, PLEURAL ARM; *PR*, PLEURAL RIDGE (ENTOPLEURUM); *S*, STERNUM; *W*, WING; *WP*, WING PROCESS OF PLEURUM.

Occasionally some of the four principal axillaries are subdivided and sometimes there occur small extra chitinizations in the axillary membrane. Thus confusion has arisen through different authors

having based schemes of general nomenclature upon some one form which happens to possess a prominent individual peculiarity.

Jurine (1820) first described in *Xylocopa violacea* the sclerites of the wing base and gave them individual names. The first he called the *grand humeral* in the front wing and the *scutellaire* in the hind wing; the second the *petit humeral* in the front wing and the *diademal* in the hind; the third the *petit cubital* in the front wing and the *furcha* in the hind; the fourth the *naviculaire* which occurs in the fore wing only of *Xylocopa*.

In the same year Chabrier (1820) described the axillary sclerites of *Melolontha vulgaris* and named the three principal ones the *humerus*, the *omoplate*, and the *onguiculaire*, respectively.

The axillaries were next described by Straus-Dürckheim (1828) in *Melolontha vulgaris*. He called them collectively the *epaulieres* in the elytrum and the *axillaires* in the hind wing, while he designated the individual sclerites numerically according to their order in each case. In the wing base of *Melolontha* there are four sclerites, but one of these is an accessory plate not represented in other forms, while the fourth of Orthoptera and Hymenoptera is not present. Hence the individual designations of anterior, second, third, and fourth axillaries used by Straus-Dürckheim can not be consistently applied in the various orders, the third in the *Melolontha* series being an extra piece.

Amans (1885) made a comparative study of the wing articulation in all the insect orders. He recognized three proximal articular sclerites which he named individually the *sigmoide*, the *median*, and the *terminal*, while he designated as *retro-median* the distal median plate or plates. He accurately described all of them and their relations to surrounding parts. Little can be added to his account.

Lowne (1892) in studying the blowfly called the first axillary the *dens*, the second the *unguiculus*, and two parts of the third the *metapterygium* and *deltoid*.

Voss (1905) in describing the external anatomy of *Gryllus domesticus* has given the best detailed account of any one species. Unfortunately, however, the cricket does not afford a typical example of the subject. Although Voss includes in his excellent paper a review of the wing articulation in all the orders, yet he bases his scheme and system of nomenclature on *Gryllus*, in some species of which the first axillary sclerite is divided into two. This same condition occurs also in some of the Locustidæ, but, as far as the writer has observed, is confined to the Locustidæ and the Gryllidæ, and is not constant in either of these families. It certainly can not be regarded as typical. However, the fourth primary axillary is present in *Gryllus*, and Voss's nomenclature is as follows: The two parts of the first axillary and the fourth, which articulate the wing to the back, are named

the anterior, middle, and posterior tergal plates (*Tergalplatten*), respectively; the second, articulating with the pleural wing process, is the middle hinge plate (*Mittlegelenkplatte*); while the third is named the posterior anal hinge plate (*Analgelenkplatte*).

Berlese (1906) in treating of the wing articulation, as in his treatment of the thorax, attempts to line up the parts in four consecutive series corresponding with the division of the tergum. In order to make his scheme consistent, he calls the hairy pad representing the tegula, on the front edge of the wing base, the *acroptero*. The first and second axillaries, though figured as perfectly distinct, are included under the name *proptero*, the third is the *mesoptero*, while the name *metaptero* is given to a rare sclerite in the axillary membrane which does not correspond with the fourth sclerite of Orthoptera and Hymenoptera. The latter Berlese identifies in *Acridium* as the " mesoptero," although a sclerite is present in *Acridium* which in every way corresponds with his " mesoptero " of other orders.

The writer retains in the present paper the general term of *axillaries* used by Straus-Dürckheim, and designates the individual sclerites as the *first, second, third*, and *fourth*, though, as already pointed out, this enumeration does not correspond with that of Straus-Dürckheim. (For synonymy see Glossary.)

It will not be necessary to describe in detail the axillary parts in each order. They can be sufficiently made out by a study of plates 47, 48, 64–69, and a comparison with text figs. 1 and 5 will show the general plan which prevails. The four principal axillaries are indicated by the numerals 1, 2, 3, and 4; by the abbreviations 1 *Ax*, 2 *Ax*, 3 *Ax*, and 4 *Ax*; or by shading in transverse lines for the first and fourth, in oblique lines for the second, and in longitudinal lines for the third. The median plates are indicated by broken oblique lines. The articulation of the sclerites to the notum is shown in figs. 75, 90, 96, 127, 128, 129, 131, 136, 150, and 161, and by text figs. 1 and 6.

The wing base is a difficult subject to illustrate because the small sclerites are so easily turned in slightly different positions and then present very different appearances. Most of the drawings have been made by getting first a camera lucida sketch of the specimen mounted in water or glycerine and flattened out under a cover glass, and then drawing in the details from dissections and a closer examination under a binocular microscope. But perhaps a dozen different drawings could be made from the same specimen all differing in details. The following are general descriptions of the specific characters of the various elements of the wing base.

The tegula (*Tg*).—This is usually a membranous or semichitinous pad-like lobe developed on the anterior membranous part of the wing root near the base of the costal vein. It is nearly always made con-

spicuous by the long hairs upon it. (As typical examples see 60–63, 185, 186, 188, 200, *Tg*). In the Diptera, Hymenoptera, and Lepidoptera the tegula is highly developed in the mesothorax as a large scale-like lobe overlapping the base of the wing. (Diptera, 210, 212; Hymenoptera, 205, 206; Lepidoptera, 149, 150, 202). In the Lepidoptera the tegula is so large that it is supported by a special plate of the mesonotum (150, 156, *tg*), which in turn is supported by a large tegular arm (153, 154, *tg_1*) from the base of the pleural wing process (*WP*).

The tegulæ of the Lepidoptera must not be confounded with the *patagia* which occur in some families of this order. The *patagia* are large thin lobes developed on the pronotum and are specially well developed in such genera as *Agrotis* and *Geometra*. They are simply thin expansions of the pronotum. In *Agraulis* they may be seen in an intermediate condition.

Lowne (1892) uses the term " epaulet " for the tegula of the blow-fly. He says that it does not correspond with the tegula of the Hymenoptera. They certainly have identical situations on the wing base, however, and it is hard to see how they could be independent organs. Lowne's objection is based on the relative position of the anterior spiracle, but the spiracle belongs to the pleurum and its position in the two orders is different on account of the different modifications of the pleurites. It is the spiracle that is shifted and not the tegula.

The first axillary (*1, 1 Ax, transverse shading*).—This sclerite is supported by the anterior notal wing process (*ANP*) and can readily be determined by this connection. It consists of a flattened body articulating externally with the second axillary, and of a curved anterior neck which abuts against the head of the costal vein (*C*). In some cases the neck is absent and then the first axillary is separated from the costa. Sometimes, as in a few Orthoptera, the neck is detached from the body and appears as an independent sclerite.

The second axillary (*2, 2 Ax, oblique unbroken shading*).—This is the pivotal sclerite of the wing base, that is, the one by means of which the wing rests and turns upon the wing process of the pleurum (text fig. 6). The articulation is generally by means of a large ventral process of the axillary which fits against an articular surface on the posterior side of the wing process. The dorsal surface of this sclerite articulates by a long ridge with the outer edge of the first. Its anterior end is usually associated with the head of the radial vein of the wing (*R*), being either fused with it or contiguous to it (text figs. 1, 5). There is generally a large muscle disk attached by a ligament either directly to the posterior end of the second axillary (199, *MD*) or to the axillary membrane near it. In an exceptional case (*Cyllene* 140) it is attached to a special process of the notum (*o*). The ven-

tral end of the muscle inserted upon this disk is attached to the anterior edge of the metacoxa in beetles. This is probably the principal muscle concerned in bending the wing toward the body.

The third axillary (3, 3 Ax, longitudinal shading).—This sclerite serves principally as a means of folding the anal region of the wing. When the fourth is absent it articulates directly to the posterior notal wing process. It nearly always presents a scoop-like muscle process on the side next the body at right angles to its long axis. The muscle inserted upon this turns the third axillary on its axis and thus causes a folding of the anal region of the wing. In the beetles this muscle is attached by a ligament first to a smaller accessory sclerite. The outer edge of the third axillary is always connected with the bases of the anal veins; frequently the latter are fused with it by a common flexible chitinous base.

The fourth axillary (4, 4Ax, transverse shading).—When this small sclerite is present it forms the posterior hinge plate of the wing, intervening between the posterior notal wing process (*PNP*) and the third axillary.

The median plates (oblique shading in broken lines).—These lie between the base of the radius (*R*) and the third axillary. They are variously developed but are principally associated with the bases of the media, the cubitus, and the first anal when the latter is separated from the other anals. Often one of them is fused with the third axillary and sometimes none of them is present.

The axillary membrane (AxM).—This is specially developed along the anal margin of the wing base where it is bordered by the axillary cord. It nearly always forms an ample expansion here, but in the wings of flies and the elytra of beetles it forms large folded lobes. These are called the *squamæ* or *alulæ* in the Diptera (212, Al). The similar membranous lobes under the elytra of some beetles (131, Al) are certainly the same things as the alulæ of Diptera. Comstock and Needham (1898) have already suggested this and cited the marginal cord-like structures (131, AxC) arising from the posterior angles of the scutellum as evidence.

Axillary cord (AxC).—This is the corrugated cord-like thickening along the posterior margin of the axillary membrane. The pair, one on each side, originate from the posterior lateral angles of the notum, and are thus valuable marks in determining the limits of this plate when the latter is obscured by close connection with the parts following.

The wing veins (C, Sc, R, M, Cu, A).—Most of these are connected or associated in a very definite and constant manner with the sclerites of the wing base. The latter are certainly a valuable asset in the identification of the veins in the different orders. Comstock and Needham (1898, 1899), however, have left little to be said on this

subject, and a study of the axillaries simply confirms the results of these authors derived from a study of the venation itself.

The general relation of the veins to the axillaries is shown in text figs. 1 and 5. The *costa* (*C*) does not connect with any of them. Its base very generally forms a separate piece from the main costal shaft, and is connected by strong membrane with the preparaptera of the pleurum. This separated costal head will be seen clearly by a review of Plates 64–69.

The head of the *subcosta* (*Sc*) articulates with the anterior end of the neck of the first axillary, except in rare cases of special modification. (For typical examples see 184, 187, 201, 206.) The base of the *radius* (*R*) is nearly always more or less closely fused with the base of the subcosta (*Sc*), but it is clearly connected also in a great many cases with the anterior end of the second axillary (182–184, 185, 186, 192, 198, 203, 204, 208). In other examples its head is only contiguous to the third axillary (185, 188, 191, 202, 209, 210, 211, 212). In a few beetles the radius and second axillary are separated by a wide membranous space (193, 194).

The *media* (*M*) and the *cubitus* (*Cu*) are closely associated with each other at their bases and with the median plates. A simple arrangement is shown in the wings of *Corydalis cornuta* (200, 201). But both the media and the cubitus are so frequently fused with the radius that their basal parts are difficult to determine in a definite manner (186, 187, 202, 203, 205, 206, 207). In other cases they are perfectly distinct at their bases (192, 194, 195, 198, 200).

The first anal vein (1*A*) is separated from the rest of the anals in the Orthoptera by the *anal fold* (see figures on Plates 47, 48). The only apparent exception to this noted by the writer is in the front wing of *Gryllus* (67). In the wing of a nymphal mantid (59) the first anal (1*A*) clearly arises at the base of the wing, independent from the rest of the anals. Comstock and Needham (1898, '99) have shown the same thing in a drawing of the wing of a cockroach nymph. The other anals generally arise from a common base, which is connected or fused with the third axillary. The *vena dividens* (60; *D*) is not a primary anal, but a secondary vein developed in the first anal fold (62, 64, 66, *A F*). In most other orders the anals are fewer, and the first is not specially separated from the rest.

The peculiar structure of the base of the wing in dragonflies will be described under the Odonata in Section VII.

VI. GENERAL CONCLUSIONS.

1. The fourth head segment, apparent in some of the lowest insects, is still regarded as a doubtful metamere by some embryologists. Assuming its genuineness, the following general statement seems pretty well established: The head of insects is composed of six con-

solidated primary segments, with the appendages of the following or neck segment attached to it forming the labium, and sometimes also with the sternum of this segment intimately fused into its ventral surface forming a gular sclerite.

2. The microthorax is formed from the embryonic segment immediately following the last of the consolidated head metameres. It is the segment of the neck of the adult. Its sclerites form the cervical sclerites of the neck, often reduced or rudimentary, and the gular plate of the head when such a plate is present. Its appendages always fuse with each other, and become closely associated with, generally attached to, the base of the head, and constitute the labium.

3. The thorax proper consists of three segments, or of three with the tergum of the first abdominal segment added in the Hymenoptera. These three segments are primary metameres, and there is no real evidence of each having been formed through a fusion of two or more primitive segments. The original thoracic region may have consisted of more than three segments, but if so, the extra segments have disappeared and have taken no part in the formation of the thoracic sclerites in modern insects.

4. The thoracic sclerites in all insects conform to one definite plan represented diagrammatically in fig. 3. The sclerites are subdivisions of the wall of one primitive segment, and the apparent double nature of each segment is secondary. Characters that have been urged as special evidence to the contrary, such as the equivalence of the episternum and epimerum and the double structure of the coxa in some orders, lose their significance when nymphal, larval, and pupal forms are examined. The episternum and the epimerum are subdivisions of one original plate on the side of the segment, and the posterior segment of the coxa shown by some orders is simply a detached piece of the epimerum fused upon the coxa in the adult stage.

5. The primitive tergum is a single undivided plate from the entire lateral margins of which the wings arise. This simple tergal structure is shown by the nymphs of all the lower insects and by many larvae and pupae and by the adults of Orthoptera. In the adults of all the other principal orders, however, there is present behind this wing-bearing plate or true notum a second tergal plate, the postnotum or pseudonotum, developed in the intersegmental membrane of the nymph or pupa, having no connection with the wings, but attached to the upper ends of the epimera.

The notum presents three fundamental ridges on its ventral surface as shown in text fig. 2. Its subdivisions do not, in most cases, closely conform with these ridges, nor do they strictly correspond in all the orders. They are in general similar but not necessarily homologous.

6. The pleurum consists fundamentally of a plate strengthened internally by a heavy, inflected, median, vertical ridge to support the wing above and to carry the leg below. Thus it has become divided into the episternum anteriorly and the epimerum posteriorly, separated externally by the pleural suture along the line of the internal pleural ridge. (See text figs. 3 and 4.) The wing support forms a wing process and the coxal support the coxal process of the pleurum. In front of the episternum there is in some of the lower insects a preepisternum. Along the base of the wing parapteral plates are developed. In front of the coxa is the trochantin, a plate possibly derived from the sternum, articulating above with the episternum and below forming the ventral articulation of the coxa.

7. The wing is hinged to the notum on the two notal wing processes, and is supported from below upon the wing process of the pleurum.

In the Ephemerida and Odonata the chitinous wing base is directly continuous with the walls of the thorax. In all other orders there is an articulation formed by several axillary sclerites in the membranous base of the wing. Three of these are of definite characteristic shape and of constant recurrence in all the orders and are present in the elytra of beetles and the halteres of flies. In the Orthoptera and Hymenoptera a fourth sclerite occurs, and this number may be regarded as the full complement. When four are present the first and fourth articulate with the anterior and posterior notal wing processes, respectively, the second articulates with the wing process of the pleurum, while the third supports the anal veins and is concerned in the plication of the anal region when the latter is folded. Where the fourth is absent the third articulates with the posterior notal process.

VII. SPECIAL CHARACTERS OF THE ORDERS.

A. CHILOPODA.

A study of the Chilopoda in connection with a study of the insect thorax brings out the following two interesting features:

1. A serial examination of the pleurum of *Mecistocephalus* (20), *Scolopocryptops* (21), *Lithobius* (22), and *Cermatia* (23) appears to indicate that only one plate (*Pl*) of the numerous pleurites on each segment in the lower Chilopoda (20) persists in the higher (23), and this plate is suggestive of being the one from which the episternum and epimerum of the Hexapoda are formed. Compare *Cermatia* (23, *Pl*) with the *Melanoplus* nymph (56, *Eps* and *Epm*).

2. The trochantin (*Tn*) appears to be originally a lateral subdivision of the sternum (20). The part behind the coxa disappears (21, 22) while the part in front extends upward to the pleurites. In *Cermatia* (23), however, it is gone entirely.

These points are simply suggestive and it is not claimed that a close relation necessarily exists between the Chilopoda and the Hexapoda. Verhoeff (1903), however, goes further than this and identifies both the episternum (coxopleure) and epimerum (anopleure) with separate plates of the chilopod pleurum.

<center>B. HEXAPODA.</center>

<center>I. APTERA.</center>

Since the importance of this order is philosophical rather than practical, the author has not devoted much time to its study. Moreover the external anatomy of the thorax in the three principal genera has been thoroughly exploited by Verhoeff (1903, 1904a).

As is well known, the Japygidæ possess a small intercalary tergal plate between the pronotum and the mesonotum and another between the latter and the metanotum. By many authors these are regarded as rudiments of primitive segments and the primitive thorax is conceived to have been composed of three pairs of segments described and named by Verhoeff (1903c, 1904a) as follows: The microthorax and prothorax, the stenothorax and mesothorax, and the cryptothorax and metathorax. But this subject has been discussed in Section II, dealing with the segmentation of the head and body (p. 519).

Verhoeff (1903) describes the pleura of all three segments of *Japyx* as very similar to the pleurum of *Lithobius*. He shows in *L. forficatus*, however, two plates above the one attached to the coxa (22, *Pl*) instead of one as shown by the species figured in this paper (22). The microthorax is represented by a sternal plate only. In *Lepisma*, according to Verhoeff, the prothoracic pleura have all the parts of the pleura of Blattidæ and Euplexoptera (Dermaptera), but the parts are rudimentary in the mesothorax and the metathorax. The microthorax in this genus, also, consists of a large sternum but has no pleural or tergal plates. In *Machilis* the three segments differ much from those of either *Japyx* or *Lepisma*. The microthoracic sclerites and the pleurites of the other three segments are almost lacking, while the terga are largely developed and reach far down on the sides of the thorax.

In *Japyx* each thoracic segment bears a spiracle, while a fourth spiracle is present close to the lateral margin of the mesosternum and near its posterior edge. Hence, this spiracle must be the spiracle of a degenerate segment.

Verhoeff (1903) regards the Thysanura not as insect " progenitori," but as a degenerate residuary branch of the primitive wingless insects. This view is undoubtedly the correct one.

II. EPHEMERIDA.

Species studied.—Hexagenia bilineata (1, 2, 3, 4).

Characteristics.—Shows little similarity to other orders of insects, except to Odonata, which are suggested by structure of wing articulation. Notum and pseudonotum present in mesotergum and metatergum. Lateral parts of mesonotum (4) complicated by irregular confusion of elevations and depressions. Axillary cords (*Ax C*) arising from middle of posterior edge of notum, pseudonotum hidden from above. On mesopleurum (1) wing process (*WP*) and pleural suture (*PS*) present, but episternum and epimerum are regions not definitely defined as plates. Epimeral region continuous with pseudonotum (*PN*). Wing veins flexible at base, merging into edges of tergum. Only one axillary sclerite developed (*4, 1 Ax*). Metatergum smaller than the preceding (3), both notum and pseudonotum present. Metapleurum with distinct wing process (*WP*), but without definitely formed pleurites or pleural suture.

III. ODONTA.

Species studied.—Libellula auripennis (5, 6, 18, 19), *L. pulchella* (16), *Pachydiplax longipennis* (7, 10, 15, 17), Libellulidæ; *Lestes uncatus* (8, 9). *Enallagma durum*, Agrionidæ; Gomphus brevis (11, 13), *G. plagiatus* (12, 14), Æschnidæ.

Characteristics.—1. Microthorax represented in both nymphs and adults by a number of plates on sides of the neck (5, 6, 8, 9, 12, *mi, 1 mi, 2 mi, 3 mi, 4 mi*) closely associated with side of the prothorax and forming a long arm on each side of neck reaching forward into concavity of the back of head.

2. Pronotum topographically divided into three distinct transverse lobes (5, 7, 8, 9, 12, 13, *N*), the third often with a descending postepimeral strip (5, 7, 12, *a*).

3. Prothoracic pleurum shows an evolution from such simple forms as shown by nymph of *Lestes uncatus* (8) and adult of *Pachydiplax longipennis* (7) to forms such as *Gomphus pagiatus* (12) and *Gomphus brevis* (13) where epimerum (*Epm*) forms principal plate on side, episternum being divided into a small upper piece (*eps*) fusing with epimerum (12), and into a larger ventral plate (*Eps*) fused with lateral plate of presternum (*Ps*).

4. Presternum (*Ps*) of the prothorax varies from a transverse plate with expanded lateral part (11), to a condition where it consists of two plates independent of the sternum and lying at sides of the latter (5, 6, 7, 9, 10). These plates in some forms, as shown under 3, completely fuse with lower subdivision of episternum (11, 12, 13).

5. Prosternum connected with the mesosternum by two slender rods (6, 7, 10, 11, 18, *b*).

6. Prothoracic spiracle plates closely associated with mesothorax in the nymph (14, 16, Sp). In the adult they unite with each other across the back, thus forming a complete spiracular dorsum (18, g) which fuses with mesothorax in front of declivous part of the latter formed by dorsal parts of episterna.

7. Trochantin lacking in both nymphs and adults.

8. Coxæ of all the segments in the nymphs articulate ventrally with the sternum by a special condyle (11, 16, d).

9. Episterna of mesothorax and metathorax subdivided in both adults (18, 19) and nymphs (14, 16) into an upper plate (eps) and a lower plate (Eps). In mesothorax the upper meets its fellow of opposite side along the mid dorsal line between the true mesonotum and the prothoracic spiracular bridge (18 g). An old nymph (14) shows an intermediate condition of this modification. In metathorax the upper plate of episternum (eps_3) fused with preceding epimerum (Epm_2). Hence, the two oblique sutures on side of combined meso- and metapleura are the two pleural sutures (16, 18, PS), while the incomplete middle one is the remnant of the intersegmental suture. In metathorax the epimera (18 Epm) meet each other along the mid ventral line behind metasternum, just as do episterna of mesothorax in front of mesotergum.

10. Pleural wing process (18, 19) divided into two arms, the posterior of which is the true wing process (WP) articulating with wing, while the anterior (h) is an arm supporting the large costal lobe of humeral angle of the wing.

11. The flexible bases of wing veins (17) merge into edges of notum as in Ephemerida. Only one distinct axillary is present (17, $1.1.x$). Base of the costa (17, 18$_1$, C) forms a large tripartite lobe at humeral angle of wing supported on anterior arm (h) of wing process (18, 19). Median point of wing base, formed principally by base of radius, articulates, by a ventral process, with true pleural wing process (18, 19, WP). This process thus corresponds with second axillary of other orders.

Lendenfeld (1881) has made an exhaustive study of the details of the thoracic structure and the wing articulation in Odonata. If the reader is interested in minutiæ and in cumbrous Latin names he is referred to the work of this author. Lendenfeld's nomenclature can not be adopted because it is not based on the idea of serial segmental homology.

The muscles of the wings in Odonata differ from those of all other orders in being inserted upon the bases of the wings instead of upon the neighboring parts of the notum and plenum. As described by Lendenfeld (1881) the set of eight muscles in each wing are as follows: (1) *Abductor*, (2) *pronator radii primi*, (3) *flexor*, (4) *flexor radii quinti*, (5) *adductor radii quinti*, (6) *pronator*, (7) *supinator*,

(8) *tensor.* All of these but (5) are attached to the sclerites of the pleurum and all but (8) are inserted upon the base of the wing either directly or by long tendons. (5) arises from a process of the notum, while (8) is inserted not upon the wing base but upon neighboring plates of the notum.

<center>IV. ORTHOPTERA.</center>

Species studied.—*Spodromantis guttata* (24, 25, 26, 27, 28, 30, wings 61, 62), Mantid nymph (34, 39), Mantidæ; *Byrsotria fumigata* (29, 32, 33, 34), *Ischnoptera hyalina* (35, 36, 37), *Blatella germanica* (38, 40, wing bases 185, 186), Cockroach wing, diagrammatic (60), Blattidæ; *Microcentrum laurifolium* (39, 41, wings 63, 64), *Anabrus simplex* (42, 43), Locustidæ; *Gryllus pennsylvanicus* (45–50, wings 66, 67, 188), *Gryllotalpa borealis* (wing 65), Gryllidæ *Melanoplus femur-rubrum* (51, 52), *Melanoplus* nymph (55, 56, 58), *Hippiscus phoenicopterus* (53, 54, 57), *Dissosteira carolina* (70, 71, wings 68, 69, 187, 189), *Acridiidæ.*

Characteristics.—1. Microthoracic sclerites of neck present in nearly all species and often highly developed, consisting of tergal, pleural, and sternal plates.

A good example is afforded by *Spodromantis guttata* (24, 25). The tergal plate is in this species a narrow U-shaped band (24) open posteriorly, but the pleural plates are so large that they greatly encroach upon the dorsal surface of the neck. The pleurites form a series of four sclerites on each side (25), the two of the third pair meeting each other on the mid ventral line. Anterior to these are two transverse sternal plates. The submentum (25, *Sm*) is clearly supported by the pleural and sternal microthoracic sclerites.

The microthorax of Blattidæ, as represented by *Ischnoptera hyalina* (36, 37), is similar to that of the Mantid. Here, however, the tergal sclerites have the more usual form of two narrow longitudinal plate (36). In *Gryllus* (45) the sternal plates are broken up into two transverse series of smaller sclerites. The labium (*Sm*) is here, also, closely associated with the microthoracic plates. *Anabrus simplex* has only one plate on each side of the neck. In the Acridiidæ there is a chain of three small cervical sclerites (51, *Mi*) on each side connecting the head with the prothorax.

2. Pronotum in general shows a tendency to crowd out the pleurites of its segment by a downward growth on each side over pleural regions.

In the lower families this is less evident and in the Mantidæ (26) and Blattidæ (29) the propleurum presents all the parts of any complete generalized pleurum, namely, an episternum (*Eps*), an epimerum (*Epm*), a preepisternum (*Peps*), and a trochantin (*Tn*) carrying the ventral coxal articulation (*TnC*), also a pleural suture

(PS) separating the episternum and epimerum externally, and a pleural ridge internally. In *Gryllus* (46) the parts are highly modified, but all are represented. The pleural ridge develops a large scapula-like internal plate ($P.A$) lying within the notum. In *Anabrus* the preepisternum is not a distinct plate. It is when the Acridiidæ are reached, however, that the greatest modification is found. Here the pronotum (51) extends downward on the side to the base of the leg reducing the episternum (Eps) to a small plate in front of the coxa, and the epimerum (Epm) to a small plate behind the coxal articulation and fused to the notal rim. A rudimentary trochantin (Tn) is also present.

In thus usurping the territory of the pleurum the pronotum has also taken over the function of the former and has become modified accordingly. An inner view (52) shows a prominent pseudopleural notal ridge (NR) bearing an arm (NA) near its lower end, just as does a normal pleural ridge (see 44, 55), and terminating below in a pseudopleural coxal process ($NCxP$) to which the coxa is articulated. A large posterior reduplication (Rd) back of the posterior groove and ridge (51, 52, z) overlaps a large part of the mesothorax.

The Acridiid pronotum is thus highly specialized, doing duty as both notum and pleurum, and its subdivision into four transverse parts can not reasonably be cited as a typical example of the quadruple structure of the insect tergum. Yet it is invariably used to illustrate the prescutum, scutum, scutellum, and postscutellum. But it is clearly illogical, as shown in another part of this paper, to offer as "typical" an example that is confessedly not so!

3. Meso- and metapleura closely resemble each other. In most cases illustrations of either one will serve for both.

In the Mantidæ (27, 28) the pleural suture (PS) is nearly horizontal, but otherwise the meso- and metapleurum is of the typical generalized form. (Compare 27, 28, with text figs. 3 and 4.) In Blattidæ (*Byrsotria fumigata* 32) the pleural parts are modified on account of the flattened shape of the body, but in a side view (*Ischnoptera hyalina* 35) the typical structure can be made out. The pleural suture (PS) separates the small dorsal epimerum (Epm) from the larger ventral episternum (Eps). An internal view (33) shows a pleural ridge (PR) and arm (PA) in normal relations to the other parts. One preparapterum (P) is usually present, and below this an indistinct preepisternum (35, $Peps$) fused with the episternum (Eps). At least it is evident that if a preepisternum is present it must occupy some such position. Yet Verhoeff (1903) regards the subdivision (eps) on the posterior edge of the episternum (Eps) as the "katopleure," while the plate he so designates in the Euplexoptera lies before the episternum. This Euplexopteran sclerite (94, $Peps$), then, is Verhoeff's "katopleure" or the preepisternum ($Peps$) of the

present paper. Now, to homologize the preepisternum of the Euplexoptera (94, *Peps*) with this posterior subdivision (*cps*) of the Blattid episternum (32, 34, 35) requires too much anatomical contortion, and the writer prefers to call the subsclerite in question (*eps*) simply a part of the episternum (*Eps*). Comstock and Kochi (1903) call it the "second antecoxal piece," but it is unnecessary to give it even this designation, which is also undesirable, because misleading.

The trochantin of the Blattidæ is likewise subdivided by an oblique suture into a dorsal part (35, *Tn*) and a ventral part (*tn*). The latter is identifiable as the trochantin by its coxal articulation (32, 35, *Tn'*). Comstock and Kochi (1902) call it "the antecoxal piece." Verhoeff (1903) recognizes it as the trochantin.

In the Locustidæ (43, 44), the Gryllidæ (47) and the Acridiidæ (57, 70, 71) the preepisternum (*Peps*) is separated from the episternum by a more or less distinct, though variable, suture. This interpretation may appear doubtful, but a line is distinct in the Acridiid nymph (55, 56) separating a large preepisternum (*Peps*) from the episternum (*Eps*). In *Anabrus* (43) the preepisternum (*Peps*) falls in line with the presternal plate (*Ps*).

A study of nymphal forms (55) shows that the paraptera (*P*), the upper end of the pleural ridge (*PR*), and the wing process are developed only in connection with the adult wing. Short-winged adults, however, such as *Anabrus simplex* (43, 44), have these parts (*P*, *WP*) present, though somewhat rudimentary.

4. Meso- and metanotum similar in most cases and often structurally identical.

In *Blatella* (38, 40) each is so simple in its construction that it could be taken as a diagram of the generalized notal plan of structure. (See text figs. 1 and 2.) Ventrally (40) it presents simple anterior and posterior marginal notal ridges (*ANR*, *PNR*), the latter at the front of a posterior reduplication (*Rd*), and a median V-shaped ridge (*V*) or "entodorsum" of Amans (1885). These three ventral ridges form lines on the surface (38, *anr*, *v*, *pnr*) marking off four apparent notal subdivisions. The metanotum of a short-winged female of *Gryllus pennsylvanicus* is very similar (50); that of a long-winged form differs in shape and has the anterior phragma (*Aph*) highly developed, but is yet of the same fundamental generalized type. In *Microcentum* the V-shaped ridge (*V*) is rudimentary in both mesonotum (41) and metanotum (39), while in the Mantid adult (30) and nymph (31) its apex continues forward as two parallel median ridges to the anterior marginal notal ridge. In Acridiidæ (54) there is present an extra ventral ridge (*ss*) consisting of two arms diverging outward and forward from the middle of the posterior notal ridge (*PNR*). The arms of this ridge (*ss*) cross over the arms of the flattened and almost obsolete V ridge (*V*). Their

bases form lines on the dorsal surface (53 *s*) which mark off two oval posterior lateral areas not represented in other families.

If the four divisions of the notum (38), as marked out by the three ventral ridges (40), are called the prescutum, scutum scutellum, and postscutellum, it must be borne in mind that they are not homologous with the divisions so named in the tergum of Lepidoptera, Hymenoptera, and Diptera. The first division is a narrow marginal strip carrying the prephragma (.1*ph*) when this is present. The second is a large bilobed plate carrying both the notal wing processes (.1*NP*, *PNP*), the third consists of a triangular median area and of two posterior lateral arms, the fourth is a posterior marginal band consisting of the posterior reduplication (*Rd*) and terminating laterally in the axillary cords (.1*xC*). This last subdivision can in no way be identified with the " postscutellum " of other orders, such as Coleoptera—the representative of this plate is lacking in Orthoptera.

5. Pseudonotum absent in both mesothorax and metathorax. Posterior marginal part of notum, which some entomologists have called " postscutellum " in Orthoptera, *not* the homologue of this plate in other orders.

In many Orthoptera, especially the Acridiidae (57), the first abdominal tergum (*1T*) presents an anterior subdivision (*1t*) whose median dorsal part fuses with the metanotum, but whose lateral parts are mostly free from the metathorax, and on each side enter into the formation of an arm of the first abdominal tergum, extending downward before the auditory organ (.1*u*). Internally, on the line between these two subdivisions of the first abdominal tergum, is a prominent ridge. In other Orthoptera this anterior subdivision and the ridge are less developed, in some cases it amounts to only a thinner anterior area which is overlapped by the reduplication of the metanotum.

This abdominal tergum could claim no place in the present discussion were it not that many entomologists have regarded its anterior subdivision as a part of the thorax. Voss (1905), for example, has identified it as the pseudonotum (postscutum, Voss) of the metathorax and the internal ridge as the postphragma. The part in question, however, and the main plate of the first abdominal tergum (57, *1t* and *1T*) are unquestionably anatomically continuous. Moreover, the first is best developed in the Acridiidae, while in Blattidae it is represented only by the weakly chitinized anterior half of the tergum overlapped by the metanotum, a subdivision such as all the abdominal terga present. Berlese (1906) regards it as a part of the first abdominal tergum, but he also thus identifies the pseudonotum (postscutellum) of the metathorax in Coleoptera. The present writer, however, sees no reason for regarding these parts in the two orders as the same. Anyone can see that they are not similar in appearance, and that their

anatomical structure and relation to the surrounding parts are different. Therefore, why not call one a part of the abdomen, which it actually is, and the other a part of the thorax, which it actually is?

6. Wing articulation of typical generalized type, generally four axillary sclerites present, bases of the veins mostly distinct (60–69, 185–189).

In some cases the first axillary is divided into two as in Locustidæ (*Microcentrum laurifolium*, 63, 64). Voss (1905) describes the same thing in *Gryllus domesticus*. In *G. pennsylvanicus* the neck of the first axillary is joined to the body of the sclerite by very delicate chitin, but the two parts can be demonstrated to be continuous (188).

The venation presents many modifications, but each form possesses some character which, used in strict conformity in all the families, furnishes a clue for the identification of the veins. (See Plates 47, 48, 65.) An important character is the location of the first anal fold (*1F*) in which the vena dividens (*D*) is located when the latter is present (58, 69, 185, 186, 189, *D*). It will be noticed that in all cases, except in the fore wing of *Gryllus* (67) the first anal vein (*1A*) lies in front of the anal fold (*1F*) or the vena dividens (*D*) and is independent of the rest of the anals at the base. That this is a nymphal condition is shown by the nymphal Mantid wing (59). Comstock and Needham (1898, '99) have illustrated the same thing in the wing of a young cockroach. Thus the first anal vein can be identified by its lying before the first anal fold and by its basal independence. Likewise its absence can be proved in the fore wing of *Gryllus* 67. The anal fold here appears to lie before the cubitus (*Cu*) but basally it will be found originating behind this vein. In the hind wing of the same species (66) the anal fold and first anal are normal. The first anal is frequently branched (60, 64), while in *Dissosteira* it fuses basally with what appears to be the vena dividens of the hind wing (69, 189).

The cubitus (*Cu*) and media (*M*) show a tendency to unite with each other at their bases, as illustrated in Blattidæ (60), Mantidæ (62), Locustidæ (63, 64), Gryllidæ (67), and Acridiidæ (68, 187). In the hind wings of *Gryllus* (66) and *Dissosteira* (69) the media (*M*) is fused for some distance with the radius (*R*). That the vein labeled *M* is the media in these wings can be determined by comparison with the venation of the fore wings (67, 68), where the media is separate from the radius at least to a point proximal to its union with the cubitus. In the fore wing of the Acridiidæ (*Dissosteira* 68) the costa (*C*) forms the anterior margin, while the subcosta (*Sc*) is clearly double from near the base. It is, hence, clear that in the hind wing the costa is absent and that what is here the marginal vein is the first branch of the subcosta (*Sc*).

It is interesting to observe that the tegula (Tg) is represented in both the fore and hind wings of nearly all Orthoptera by a small hairy pad on the axillary membrane between the base of the costa and the attachment to the notum.

V. PLECOPTERA.

Species studied.—*Pteronarcys californica* adult (72, 75, 78, 79, wings 182, 183, 184). *Taeniopteryx fasciata* adult, *Perla* sp. nymph (73, 74, 76, 77). *Acroneuria* sp. nymph (81), *Isogenus* sp. nymph (80).

Characteristics.—1. Microthorax not well developed, consisting generally of a chitinous band or plate on each side of neck.

2. Trochantin (Tn) of prothorax in both nymphs (73) and adults (72) inserts itself between coxa and true pleurum formed of episternum (Eps) and epimerum (Epm). Upper part of trochantin (Tn) then takes on both the function and appearance of the displaced pleurum. It articulates with dorsal edge of coxa by a special condyle $(Tn\ CxP)$, presents externally a pseudopleural trochantinal suture $(72, Tn\ S)$ and internally a pseudopleural trochantinal ridge $(74, Tn\ R)$. Continuing above the latter on true pleurum is the real pleural ridge (PR).

3. Trochantin of both mesothorax and metathorax fused in adults (78, 79, Tn) with episternum (Eps), apparently not taking part in coxal process (CxP). A nymph of *Acroneuria* (81) is similar but one of *Isogenus* (80) presents a very typical trochantin (Tn) in the mesothorax.

4. Wing bases very simple, parts of typical arrangement (182, 183). A triangular plate (C) of head of costa articulates with parapterum (78, 79, P). Wing venation shown by figs. 183, 184.

5. Meso- and metanotum divided topographically into regions (75) but not by lines or sutures. V-ridge absent.

6. Plecoptera differ from Orthoptera in specialized condition of prothoracic pleurum and in development of pseudonotum in both meso- and metatergum.

VI. CORRODENTIA.

Species studied.—*Cerastopsinus venosus* (82).

Characteristics.—1. Microthorax presents elongate plate on each side of neck, connecting with triangular lobe on posterior rim of head, and with an arm on edge of prothoracic episternum.

2. Prothorax reduced, but all plates present except a preepisternum. Epimerum largest plate. Trochantin does not articulate below with coxa.

3. Dorsal plates of meso- and metathorax (mesonotum and pseudonotum and metanotum and pseudonotum) all fused so that meso- and metaterga are solidly continuous.

4. Meso- and metapleurum (82) alike. One preparaterum (*P*) present in each forming large lobe of episternum. Epimerum fused above with pseudonotum (*PN*).

VII. HEMIPTERA.

Species studied.—*Benacus haldemanum* (83, 84, 85, 86, 87, 88, 89, wing bases 190, 191), *Amorgius americanum, Belostomida.*

Characteristics.—The following characteristics may not be general to the Hemiptera, for there evidently exist numerous structural modifications within the order. The drawings of *Benacus haldemanum* can not serve as more than a basis for a comparative study, but they illustrate the agreement of the Hemipteran thorax with the fundamental plan of that in other insects.

1. Microthoracic plates absent.

2. Trochantins (*Tn*) present in each segment, but hidden, together with bases of coxæ, by the produced edges of the pleurites (83, 85).

3. Anterior coxæ articulated to condyls carried by pronotum (83, *CxP*).

4. Posterior coxæ articulated to a condyle of the metaepimerum (84, 89, *k*), which is inserted between the coxa and the true pleural coxal process (*CxP*).

5. Preparaptera not distinct from episternum (85, 89). No postparaptera.

6. Episternum of metathorax divided into an upper and a lower sclerite (89, *Eps, Eps*).

7. Scutellum of mesonotum forms a large triangle between bases of fore wings. Mesopeudonotum absent.

8. Metanotum distinctly divided into three transverse parts by transverse lines (87, *psc, sct, scl*). A pseudonotum (87, 88, *PN*) present, very narrow mesially, expanded laterally where fused with epimera (*Epm*).

9. First abdominal tergum (87, 88, *IT*) a narrow bar fused with metapseudonotum, expanded laterally, bearing the spiracles (I *Sp*) and phragmal arms (I *Ph*).

10. Wing bases shown by 190 and 191. *C, Sc,* and *R* form large detached sclerite at humeral angle of hind wing (191) though not detached in fore wing (190). Third axillary divided and of unusual shape in fore wing (190, *3 Ax*), simple in hind wing.

VIII. EUPLEXOPTERA.

Species studied.—*Spongiphora apicidentata* (90–94, 98, 100), *S. brunneipennis* (96).

Characteristics.—This order has been specially studied by Verhoeff (1902, 1903a). The present writer has elsewhere (1908) made a comparison of the Euplexopteran thorax with that of Orthoptera and

Coleoptera. Such a comparison shows many more points of resemblance to the Coleoptera than to the Orthoptera, but at the same time the similarity is of such a nature that it may be secondary rather than phylogenetic.

1. Microthorax well developed, presenting tergal, pleural, and sternal plates (93), one of the latter almost gular in position.

2. Presternum consisting of two plates (Ps) in all three segments lying before or beside the anterior angles of the sternum (91, 94, 98).

3. A preepisternum ($Peps$) well developed in mesothorax (94).

4. Trochantin (Tn) present in all three segments (91, 94, 98).

5. Propleurum (91) and mesopleurum (94) similar, differing from metapleurum (98).

6. Metapleurum (98) in appearance similar to that of Coleoptera. First preparapterum ($1P$) fused with front of episternum (Eps) and bears internally large pronator disc (100, PD).

7. Mesonotum (90, 92) simple, mesopseudonotum lacking. Metanotum (96, N) complex, presenting median groove fringed with recurved bristles (G). Metapseudonotum (PN) present, though fused with first abdominal tergum ($1T$).

8. A small rod in wing base connects with parapteral region in mesothorax (90, n) and with second preparapterum ($2P$) in metathorax (98, 100, n).

IX. COLEOPTERA.

Species studied.—*Calosoma scrutator* (102, 103, 110, 113, 127, 132, 133, wing base 193, 197), Carabidæ; *Dytiscus dauricus* (107, 108, 114, 128, 131, 136, wing base 192), Dytiscidæ; *Hydrophilus triangularis* (105, 111, 112, 125, 134, wing base 198), Hydrophilidæ; *Silpha surinamensis* (106), Silphidæ; *Melolontha vulgaris* (117, 121, 135, 138, 139, wing base 195, 199), Scarabæidæ; *Buprestis aurulenta* (95, 99, 104), Buprestidæ; *Tetropium velutinum* (123), *Cyllene robiniæ* (97, 101, 116, 119, 129, 130, 140, wing base 194), Cerambycidæ; *Dendroctonus valens* (118, 120, 122, 124, 126), Scolytidæ.

Characteristics.—1. Microthoracic plates rudimentary (95) or absent.

2. Prothoracic and mesothoracic pleura resemble each other more than they do the metathoracic pleurum. Pleurites of the first two vertical or oblique, those of the last horizontal.

3. Prothoracic pleurites commonly fused with each other and with tergum and sternum, but not reduced in size.

4. Mesothoracic pleurites (97, 101, 102, 105, 106, 107, 109) always distinct, usually oblique. Wing process (WP) often hidden by prominent upper end of episternum, but easily seen on inner surface (101, 103, 108) as is also its relation to pleural ridge (PR). Epimerum (Epm) commonly with a dorsal subdivision (epm), and

episternum (*Eps*) often divided into several parts by vertical ridges or lines (102, 109).

5. Metathoracic pleurites horizontal or nearly so (110–121). Wing process (*WP*) a prominent oblique arm arising from anterior ends of pleurites, lying just behind and parallel with a similar arm from the preparapterum which also takes part in supporting the wing. (See description under 8.) Usually a more or less prominent supraepimeral plate present (111–121, *epm*) to which the ends of the metapseudonotum are connected.

6. Trochantin (*Tn*) present in prothorax and mesothorax, but is usually a small sclerite at base of coxa (99, 104) concealed in coxal cavity formed by projecting pleurites. In Silphidae (106) and Buprestidæ (109) it is exposed on surface of mesothorax. Lacking in metathorax.

7. Only one preparapterum (*P*) present in either segment. Postparapterum lacking. Preparapterum of mesopleurum usually a small plate or rod lying before the wing process (102, 103, 107, 108). Sometimes it bears a pronator muscle disk (101, *P*, *PD*).

8. Preparapterum of metathorax in most beetles fused with an anterior subdivision (*eps*) of episternum (*Eps*) as in *Cyllene* and *Dendroctonus* (116, 118, *P*+ *eps*), making, with the wing process (*WP*), two conspicuous wing-supporting arms. In lower forms, like *Calosoma* (110, 113) and *Dytiscus* (114, 115) the parapterum (*P*) and its disc (*PD*) are entirely free from the episternum (*Eps*) though closely articulated to front of wing process (*WP*). Other forms, such as *Hydrophilus* (111, 112) and *Melolontha* (117, 121), show an intermediate condition in which the line of fusion is distinct.

9. Mesonotum (125, 127, 128, 129) generally presents a triangular scutellar area between bases of elytra. Mesopseudonotum lacking unless represented by two small plates (127, 128, 131, *q*) connecting mesonotum with metanotum.

10. Metanotum in lower families like Carabidæ (132) and Dytiscidæ (136) distinctly divided into three transverse parts (*psc, sct, scl*). The first or prescutum (132, 136, *psc*) carries the prephragma (*Aph*) and the anterior notal wing processes (*ANP*); the second or scutum (*sct*) is divided transversely into an anterior and a posterior plate by a large transverse ventral ridge (133, 137, *w*) peculiar to the Coleoptera and forming lines (132, 136, *w*) on the surface, while each of these is divided again into separated lateral regions by a median interlocking of the prescutum (*psc*) and scutellum (*scl*). Thus the scutum consists of four well-marked subdivisions, the posterior pair of which carries the posterior notal wing processes (*PNP*). The scuttellum (*scl*) consists of a median triangular area produced into a tongue on the floor of the median notal groove (*G*), formed by the entodorsum or ventral **V**-shaped ridge (133, 137, *V*),

and of two slender lateral strips forming the posterior margin of the notum and ending in the axillary cords (*AxC*).

This simple *Calosoma-Dytiscus* plan (132, 136) is distorted by modifications in the higher families, but a serial change can be traced through *Hydrophilus* (134), *Melolontha* (135, 138), and *Cyllene* (140).

11. Pseudonotum of metathorax (*PN*) well developed in all beetles (132–137, 139, 140), carrying the postphragma (*Pph*) and articulating by its extremities (*i*) with epimera of metathorax. Absent in Coleopteran pupæ (122, 123).

12. Elytra (*El*) articulated to mesothorax by the ordinary three axillary sclerites, though the first and second are sometimes fused (127, 128).

13. Wing bases of usual construction (192, 193, 194, 195, 198). Head of the costa (*C*) frequently separated from main shaft of the vein (197) and attached to the subcosta (*Sc*) by a process fitting into a cavity in the head of the latter. Venation poorly developed (196). Axillaries normal, sometimes with a small accessory piece (199).

X. NEUROPTERA.

Species studied.—*Corydalis cornuta* (142, 143, 144, 145, 147, wing bases 200, 201).

Characteristics.—1. Posterior segment of gula projects beyond rim of head and is entirely surrounded by membranous sutures, thus strongly suggesting a microthoracic origin. Between head and prothorax is a wide collar-like band open dorsally, mostly concealed within rim of pronotum. Perhaps this collar is microthoracic, but possibly it is presternum of prothorax.

2. Prothorax elongate, depressed. Notum and sternum separated by wide infolded pleuro-tergal membrane. Pleurites reduced to small plates, episternum fused with sternum. Procoxa simple, cylindrical, not double as in meso- and metathorax.

3. Meso- and metanotum sufficiently shown by figs. 142 and 143. Both notal wing processes carried by scutum.

4. Meso- and metapleurum of the adult similar (147). One preparapterum (*P'*), fused with episternum. Trochantin (*Tn*) large. Coxa of two parts, a ventral segment (*Cx*) carrying the trochanter, and a dorsal posterior segment (*epm*). A study of the pupa (145) and the larva (144) shows that the upper coxal segment is simply a detachment of the epimerum (*Epm*) fused upon the coxa (*Cx*). In the larva (144) epimerum is divided (*Epm*, *epm*); coxa (*Cx*) is simple, as in prothorax of adult. In pupa (145) lower subdivision of epimerum (*eps*) extends downward and attaches to rear side of coxa. In adult (147) this separation completed and lower plate (*epm*) of epimerum (*Epm*) entirely detached from the latter and intimately fused with coxa.

This double nature of the meso- and metacoxæ is common to Neuroptera, Mecoptera, Trichoptera, and Lepidoptera, and it has often been adduced as evidence of the double nature of the entire segment. Since, however, it can be shown in all these orders to be a purely secondary adult character, it is evident that it has no such significance whatever.

5. Wing base very simple in the pupa (141). Articular elements and bases of the veins of typical shape in adults (200, 201).

XI. TRICHOPTERA.

Species studied.—*Neuronia ocellifera* (146, 148), *Platyphylax subfasciata, P. designata,* larvæ and pupæ of unknown species.

Characteristics.—1. Only one preparapterum (148 *P*) present, fused with episternum. Pronator disc carried by upper edge of episternum.

2. Trochantin (*Tn*) of meso- and metathorax crowds episternum (*Eps*) from coxal articulation.

3. A wing of the meso- and metasternum (*S*) extends dorsally before the trochantin (*Tn*) to the episternum (*Eps*).

4. Meso- and metathorax similar to each other in size and structure.

5. Meso- and metacoxæ (*Cx*) of adult with a posterior segment (*epm*) as in Neuroptera. This can be shown by a study of the pupa (146) to be a detached piece (*epm*) of the *epimerum* (*Epm*), which has extended downward behind the coxa and fused upon it.

The Trichoptera stand in a position intermediate between the Neuroptera and the Lepidoptera. The resemblance of the Trichopteran pleurum to that of a generalized moth like *Phassus* (149) is very striking.

XII. LEPIDOPTERA.

Species studied.—*Phassus argentiferus* (149, 150, 151, 152, wing bases, 202, 203), *P. triangularis* (153, 154), Cossidæ; *Protoparce cingulata* (155–159, wing base, 204), Sphingidæ; *Citheronia regalis,* Citheroniidæ.

Characteristics.—1. Microthorax represented by one or two sclerites on side of neck (152 *mi, mi*).

2. Pronotum well developed in lower families (152 *N*); reduced and longitudinally compressed in higher families, often forming two flat lateral lobes which even become constricted at the base into two stalked plates, the patagia. The patagia are specially well developed in *Agrotis*. A comparative study would show them to be simply developments of the notum, and there is no ground for regarding them as homologues of the wings, nor even of the tegulæ.

3. Propleurum narrow (152). Epimerum (*Epm*) specially reduced, generally obsolete. Episternum (*Eps*) prolonged upward as a narrow prenotal band, overlapped by edge of notum.

4. Prothoracic coxa not articulated to true coxal process, but to a small detached plate in *Phassus* (152 p) which in *Protoparce* and *Citheronia* is fused with lower end of episternum.

5. Meso- and metathoracic coxæ (149, 153) double in adults as in Neuroptera and Trichoptera, consisting of an anterior true coxa (Cx) and of a posterior plate (cpm), undoubtedly derived from the epimerum (Epm) as in *Corydalis* and *Neuronia*. The coxæ have but little motion upon the pleurum and the principal movement of the base of the leg is in the articulation between the coxa and the trochanter.

6. Trochantin present in both meso- and metathorax (149, 153, 154, 158, 159, Tn), but more or less completely fused with episternum (Eps) above, and always closely attached to a wing of sternum (S) in front. This is exactly the same as in *Corydalis* (147) and *Neuronia* (148). Lower end sometimes projecting as a free point articulating with ventral rim of coxa and sometimes obsolete.

7. Only one preparapterum present (149, 153, P), and it is fused with episternum. Pronator disc (154, PD) carried by upper edge of episternum.

8. The pleural wing process of mesopleurum (153, 154, 159, WP) bears a large anterior arm (tg A) serving as a prop for the tegular plate of the notum (150, 156, tg).

9. Mesothoracic notum (150, 156) distinctly subdivided into a prescutum (psc) carrying the prephragma (155, Aph), a scutum divided into two lateral lobes (sct, sct) carrying the anterior notal wing processes (ANP) and, in *Phassus*, the posterior processes also (150, PNP), and into a scutellum (scl) forming a posterior triangle (scl) whose lateral angles terminate in the axillary cords (AxC). Probably in most families the posterior notal wing processes (PNP) would appear to belong to the scutellum (scl) as in *Protoparce* (156).

10. Tegulæ greatly developed in mesothorax (149, 150, 202, Tg) and attached to a special tegular plate of the notum (149, 150, 156, tg) supported by the tegular arm (153, 154, 159, tg A) of the wing process (WP).

11. Metanotum in lower forms like Cossidæ (151) similar to, though smaller than, the mesonotum (150). In higher families it becomes very much shortened antero-posteriorly, as shown by *Protoparce* (157), and greatly reduced in proportion to the mesonotum (156).

12. A pseudonotum (PN) present in both meso- and metathorax, though depressed and mostly hidden (149). In mesothorax (150, 156, PN) it carries a large postphragma (Pph). In metathorax (151, 157) postphragma (Pph) is smaller and fuses with first abdominal tergum (149, 151, $1T$).

13. In wing base (202, 203) media (*M*) and cubitus (*Cu*) fuse with base of radius (*R*). Axillaries of ordinary structure (202, 203, 204).

14. The jugum (202, *Ju*), present in lower families, is simply a lobe of anal region of fore wing and is supported by last anal vein (*3A*).

15. The frenulum (204, *Fr*) consists of a spine or bunch of bristles developed on enlarged base of costa (*C*) of hind wing.

XIII. HYMENOPTERA.

Species studied.—*Cimbex americana* (161–166, wing base 205), *Parasiloba sp.* (160), Tenthredinidæ; *Sirex flavipennis* (161, 171, 172, wing bases 206, 207) Siricidæ; *Pepsis sp.* (168, 169, 170, wing bases 208, 209) Pompilidæ; *Sphecius speciosus*, Bembecidæ.

Characteristics.—1. Pronotum (*N₁*) attached to mesothorax (160, 163, 169) and but loosely connected with prothoracic pleural parts (160, 162, 168), except in *Sirex* where prothoracic parts retain normal relations (171).

2. Trochantin absent as a distinct sclerite in all three segments.

3. Epimerum of prothorax rudimentary, forming merely a narrow posterior marginal rim on episternum (160, 162, 168, 171, *Epm*).

4. Mesonotum divided into three distinct divisions (160, 161, 163, 170, *psc*, *sct*, *scl*), first of which (*psc*) sometimes entirely concealed by pronotum (169, *N₁*). Scutum (161, 170, *sct*) carries anterior notal wing processes (*ANP*) while scutellum (*scl*) carries posterior wing processes (*PNP*) and axillary cords (*AxC*). Mesopseudonotum (160, 161, 163, 169, 170, *PN₂*) carries large postphragma (161, 163, 170, *Pph*) projecting downward and backward into metathorax.

5. Metathorax well developed and of normal shape in *Cimbex* (164) presenting all the principal pleural and tergal parts (*Eps*, *Epm*, *sct*, *scl*, *PN*). In *Parasiloba* (160) parts somewhat larger, but pleural suture (*PS*) almost horizontal. In all higher Hymenoptera (*Pepsis* 169) the metapleurites (*Eps*, *Epm*) are elongate, entirely fused with each other, obliterating the metapleural suture, and continuous with the pseudonotum (*PN₃*).

6. First abdominal tergum (*IT*) in *Parasiloba* (160) somewhat more separated from second abdominal tergum (*IIT*) than from the metapseudonotum (*PN₃*). In *Cimbex* (164) entire first abdominal segment (*IT*) attached to posterior rim of the metathorax and but loosely connected with rest of abdomen (166). In all higher families (*Pepsis* 169) the first abdominal tergum (*IT*) solidly incorporated into metathoracic wall and virtually a part of metathorax, the peduncular constriction occurring between it and second abdominal segment (*IIT*). This is probably the most distinctive character of the

Hymenoptera. The first abdominal segment is known as the *median segment* (" segment mediaire " of Latreille) and can always be identified by its spiracles (160, 164, 167, 169, ISp).

7. Tegulæ of fore wings developed as in Diptera into large scale-like plates overlapping humeral angles of wings (160, 161, 163, 169, 170, 205, 206, Tg). In hind wings they are hairy pads as in Orthoptera (207, 209, Tg).

8. Four axillaries nearly always present as in Orthoptera (205, 206, 207, 208), the first and fourth articulating with notal wing processes.

9. Head of costa in fore wings (205, 206, 208, C) separated as a humeral plate with head of subcosta (Sc) attached. Subcosta (Sc) a separate vein in fore wing of *Sirex* (206), in other forms (205, 207, 208, Sc) shortened to a basal piece between bases of costa (C) and radius (R) and fused with the detached costal head (206, 207, 208). In hind wing of *Pepsis* (209) bases of the costa (C), subcosta (Sc), radius (R), and media (M) all fused into one common head.

There is nothing in the basal structure of the veins that would discredit Comstock's interpretation of the Hymenopteran venation, though it probably does not indicate whether M is fused with R or is lacking.

XIV. DIPTERA.

Species studied.—*Holorusia grandis* (174–178, wing base 210, base of halter 211), Tipulid pupa (173), Tipulidæ; *Tabanus atratus* (179, 180), Tabanidæ; *Calliphora vomitoria* (wing base 212) Muscidæ.

Characteristics.—1. Two cervical sclerites present on each side of neck in *Holorusia* (174) and *Tabanus* (179), and several ventral sclerites in the latter and in *Calliphora*.

2. Prothorax reduced but episternum and epimerum (174, 179, Eps, Epm) present, and in *Holorusia*, pronotum (174, N_1) formed of two distinct subdivisions (sct and scl).

3. Trochantin absent in all three thoracic segments, unless the small plate (174, 179, $Tn?$) of the prothorax is a rudimentary trochantin.

4. In meso- and metathorax of *Holorusia* (174) each sternum (S_2, S_2, S_3) presents a precoxal and a postcoxal plate connecting with the episternum (Eps) and the epimerum (Epm) respectively. This is true only of the mesosternum (S_2, S_2) of *Tabanus* (179).

5. Mesopleurum of *Holorusia* of simple, typical structure (174, 176, 178); but in *Tabanus* (179) and in all higher Diptera episternum divided into a large anterior plate (eps), and a less conspicuous posterior part (Eps) entering into formation of wing process (WP). The relation of the anterior plate (eps) to the first spiracle (Sp_1) and to the other neighboring parts is so nearly identical with that of the single, undivided episternal plate of *Holorusia* (174, Eps_2)

that it can not be doubted that the sclerite in question belongs to the episternum. Some authors have regarded it as a part of the mesosternum. Among the latter are Lowne (1902), who calls it the "lateral plate" of the mesosternum. Hewett (1907) interprets it in the same way. Hammond (1881) identifies it as the "parapterum," but this is certainly stretching homologies too far, especially since a true preparapterum is present in the mesothorax (174, 176, 178, P) of *Holorusia* and two in that of *Tabanus* (179, $1P$, $2P$). Berlese (1906) regards the plate as the mesoepisternum, as also does Crampton (1909). A comparison of figs. 174 and 179 certainly suggests nothing else than that the mesoepisternum (Eps_2) of the former is simply divided in the latter into two plates (eps_2 and Eps_2).

6. Mesonotum very large (174, 175, 179, 180) and in *Holorusia* (175) definitely subdivided into prescutum (psc), scutum (sct), and scutellum (scl), but in Tabanus (179, 180) first and second parts not so distinctly separated (psc, sct). The scutum carries the anterior notal wing processes (ANP) and the scutellum the posterior wing processes (PNP) and axillary cords (AXC).

7. Mesopseudonotum very large in *Holorusia* (174, 175, PN_2), consisting of median and two lateral subdivisions, the "mediophragmite" and "pleurophragmites" of Crampton (1909), the latter connected with epimera (174, Epm). Present in pupa (173) as plate (PN_2) between the two wing-bearing nota (N_2, N_3). In *Tabanus* (179) mesopseudonotum (PN_2) narrow, reaching undivided down the side to epimerum (Epm_2), carrying posteriorly an extremely large phragma (Pph_2) extending downward and posteriorly into abdomen, making a large convex wall almost shutting off the cavity of abdomen from that of thorax.

8. Metathorax always reduced, but with the two principal pleural plates well developed (174, 177, 179 Eps_3, Epm_3) and forming a normal wing process (WP_3) supporting the halter (Hl), in every way comparable with the parts of the mesothorax (176, 178) except that the preparaterum (P) is lacking. Metanotum (174, 179, N_3) reduced to a narrow band. Metapseudonotum (PN_3) present and continuous with the epimera (Epm_3).

9. Axillaries normal, present in both wing (210, 212) and halter (211). The detailed structure of the base of the latter (211) leaves no doubt that it is simply a modified wing, while a study of a Tipulid pupa (173) shows that the halter (W_3) is truly wing like in its origin.

10. Tegula (210, 212, Tg) developed as a large hairy scale covering humeral angle of wing.

11. Alula a specially developed lobe or lobes of the axillary membrane of the wing (212, Al) bordered by the axillary cord (AxC).

VIII. GLOSSARY AND SYNONYMY.

The following principles have been used in the selection, application, and spelling of the anatomical terms here explained:

1. The same names are repeated in each segment on corresponding parts and distinguished in each by the prefixes *pro*, *meso*, or *meta*.

2. The terms proposed by Audouin (1824) are retained in all cases except where there are very strong reasons for discarding any one of them, as in the substitution of *entosternum* Chabrier (1820) for *entothorax* Audouin, and of *pseudonotum* Verhoeff (1903) for *postscutellum* Audouin as the general name of the posterior tergal plate. (See rule 8.)

3. Parts not named by Audouin have been given names selected from the works of other anatomists when such names are descriptive of the parts to which they are applied or are in accord with the general system of naming the other parts. Priority is not recognized because it would involve the retention of too many inappropriate or cumbrous terms.

4. In naming the wing veins and their branches, the names and venational system of Comstock have been used in all cases.

5. No attempt has been made to give, in the synonymy, the equivalence of terms used by systematists in different orders. Their systems of nomenclature too often show an absolute disregard for, or ignorance of, comparative anatomy.

6. The term *dorsum* is used to designate the entire back of the insect or of any part or segment, and the term *venter* is applied in like manner to the ventral surface.

7. The names *tergum*, *pleurum*, and *sternum* are used to designate all the chitinous parts of the morphological dorsal, lateral, and ventral surfaces, respectively, in any segment; the individual plates in each are called *tergites*, *pleurites*, or *sternites*. An exception to this is the use of the word *sternum*, applying also specifically to the second sternite of any segment.

8. The term *notum* is applied to the primitive wing-bearing plate of the dorsum, and is synonymous with *tergum*, except where, as in the meso- and metathorax of most adult insects, the dorsum acquires a secondary tergal plate back of the wing-bearing notum. This secondary plate is called the *postnotum* or *pseudonotum*.

9. The prefixes *pro*, *meso*, and *meta* are used only to signify that the part so designated belongs to the prothorax, mesothorax, or metathorax.

10. The prefixes *pre* and *post* are used to indicate the anterior and posterior parts, respectively, of any one segment.

11. The prefix *præ* is discarded in favor of *pre*.

12. The Greek termination *on* is replaced in all cases, for the sake of uniformity, by the Latin ending *um*. Thus, *epimerum* instead of *epimeron, elytrum* instead of *elytron.*

*Abdominal sterna (1S-XS).—*The ventral plates of the abdominal segments. The eighth and ninth carry the gonapophyses—the pieces of the ovipositor or sting.

*Abdominal terga (1T-XT).—*The dorsal plates of the abdominal segments. In Hymenoptera the first is fused with the metathorax, and is called the median segment or "segment mediaire" of Latreille.

*Accessory coxal plates (Cxa).—*Small sclerites sometimes occurring in the membrane at the base of the coxa, especially between the coxa and the trochantin. *Complimentary coxal plate* Crampton (1909).

*Accessory trochantinal plate (Tna).—*A small sclerite sometimes at the coxal end of the trochantin, but more closely associated with the trochantin than with the coxa.

*Alula (Al).—*The membranous lobe or lobes at the base of the wings of Diptera and the elytra of some Coleoptera, consisting of an expansion of the posterior part of the axillary membrane. *Alula* Kirby and Spence (1826). *Anallappen* Voss (1905).

*Anal fold (AF).—*The line of folding between the anal area and the preceding part of the wing. The *vena dividens*, when present, is developed as a secondary vein in this fold. In Orthoptera the fold is nearly always *behind* the first anal vein, or starts behind it at the base of the wing.

*Anal veins (A or 1A, 2A, etc.).—*All the wing veins caudad of the cubitus or fifth primary vein.

*Anterior notal ridge (ANR).—*The anterior ventral marginal or submarginal ridge of any notum, simple in immature forms, carrying a variously developed prephragma in most adults, and often forming a submarginal line (*anr*) on the dorsal surface of the notum.

*Anterior notal wing process (ANP).—*The anterior lateral process of the notum hinging with the wing by the first axillary sclerite of the wing base. *Apophyse humerale* Chabrier (1820). *Axillifère* Straus-Dürckheim (1828). *Tergelhebel* Voss (1905). *Precondilo* Berlese (1906).

*Anterior phragma (Aph).—*See *Prephragma.*

*Apodeme.—*Any internal chitinous projection of the body wall whether a ridge, an arm, or a pedunculated disc or cup.

*Auditory organ of locust (Au).—*The tympanum on the side of the first abdominal segment in Acridiidæ.

Axillaries (1, 2, 3, 4; 1Ax, 2Ax, 3Ax, 4Ax; indicated also by *transverse shading* for the first and fourth, *oblique* for the second, and *longitudinal* for the third). The three, or sometimes four, small sclerites at the base of the wing articulating it to the body. (See

first axillary, second axillary, third axillary, and *fourth axillary.*)
Osselets radicaux Chabrier (1820). *Epidemes d'articulation* (?) Audouin (1824). *Epauliers* of elytrum, *axillaires* of wing, Straus-Dürckheim (1828). *Axes* Kirby and Spence (1826). *Tergalplatten* and *analgelenkplatten* Voss (1905). *Pezzi articolari* Berlese (1906).

Axillary cord (*AxC*).—The thickened and usually corrugated posterior cord-like edge of the anal membrane of the wing normally arising on each side from the posterior lateral angle of the notum and thus serving as a mark of the posterior limits of the latter. *Ligamentum alœ* Lendenfeld (1881). *Cord-like structure* Comstock and Kellogg (1902). *Ligamento* Berlese (1906).

Axillary membrane (*AxM*).—The membrane of the wing base, specially evident as the very delicate membranous expansion at the posterior basal angle of the wing. The *alulœ* are extreme enlargements of this part of the axillary membrane.

Axillary sclerites.—See *Axillaries.*

Cercus (*Cr*).—The cerci are the appendicular organs of the tenth abdominal segment. *Cercus* Kirby and Spence (1826).

Cervical sclerites (*mi*).—The sclerites of the microthorax situated in the membrane of the neck. *Pieces jugulaires* Straus-Dürckheim (1828). *Prothoracic paraptera* Newport (1839). *Cervical sclerites* Comstock and Kellogg (1902). Sclerites of *microthorax* Verhoeff (1902). *Vorplatten* of prothorax, Börner (1903). *Pezzi ingulari* Berlese (1906).

Costa (*C*).—The first vein of the wing, usually forming its anterior margin.

Coxa (*Cx*).—The basal segment of the leg. *Clavicula* (prothorax), *coxa* (meso- and metathorax) Kirby and Spence (1826). *Hanche* Straus-Dürckheim (1828). *Coxa genuina* Walton (1900).

Coxal cavity (*CxC*).—The cavity on the outside of the body formed by the projecting pleurites and sternum, sometimes inclosing the coxa as in a socket.

Coxal process (*CxP*).—See *Pleural coxal process.*

Coxo-axillary muscle.—The muscle extending from a large disk of the wing base, usually attached to the second axillary, to the anterior rim of the coxa. *Muscle coxali-axillaire* Chabrier (1820).

Cubitus (*Cu*).—The fifth principal vein of the wing.

Dorsum.—The entire back of the insect or of any part or segment. *Dorsum* Audouin (1824). Crampton (1909). Used in various ways by other authors, sometimes to signify the entire upper surface, sometimes synonymous with *notum* or *tergum* and even with *scutum.*

Elytrum (*El*).—The anterior wing of Coleoptera and Euplexoptera. *Elytrum* Fabricius (1778), Kirby and Spence (1826). *Elytron* common spelling.

Entodorsum (*V*).—The ventral **V**-shaped ridge of the notum, usually separating the scutum from the scutellum. *Entodorsum* Amans (1885).

Entopleurum (*PR and PA*).—The apodeme on the inner face of the pleurum along the line between the episternum and the epimerum, consisting of the *pleural ridge* and *pleural arm* (which see). *En-topleuron* Amans (1885), Crampton (1909).

Entosternum (*Fu*).—The internal skeleton of the sternum (See *Furca*). *Entosternum* Chabrier (1820), Amans (1885). *Entotho-rax* Audouin (1824).

Entothorax.—The internal skeleton or apodemes of the thorax, including the *entodorsum*, *entopleurum*, and *entosternum*. (Audouin applied the name " entothorax " to the sternal apodemes alone.)

Epimeral paraptera (*3P*, *4P*).—The small plates in the pleural membrane below the base of the wing and posterior to the pleural wing process. Commonly there is but one present, though two occur in some of the Plecoptera. (Also called *postparaptera*.) *Costale* Straus-Dürckheim (1828). *Costa* Lowne (1892), Hewett (1907). *Epimeralgelenkplatten* Voss (1905). *Postepimeron* Snodgrass (1908). *Costal sclerite and posterior costal sclerite* Crampton (1909).

Epimerum (*Epm*, *epm*).—The principal pleural plate lying behind or above the pleural suture and pleural ridge, in general forming the posterior half of the pleurum. Its posterior dorsal angle connects with the postnotal plate of the tergum. In the metathorax of Coleoptera the epimerum commonly presents a distinct dorsal subdivision (*epm*), the " parapleur " of Kolbe (1889). *Epimère* Audouin (1824). Posterior plate of *scapularia* in mesothorax, of *parapleurae* in metathorax, Kirby and Spence (1826). *Second ili-aque* of mesothorax, *seconde ischion* of metathorax, Straus-Dürckheim (1828). *Postpleuron* Amans (1885). *Epimeron* Kolbe (1889), Crampton (1909). *Anopleure* Verhoeff (1903).

Episternal paraptera (*P*, *1P*, *2P*).—Two small pleural plates between the episternum and the base of the wing, and before the pleural wing process. The large pronator muscle of the wing is inserted upon the inner faces of both of them, upon the inner face of one only, or upon a large chitinous disk carried by either one. Frequently one is absent or rudimentary; only rarely are both absent, except in wingless species. In the Coleoptera only one epimeral paraterum is present, and in the metathorax, except in the lowest families, this one is fused with the anterior edge of the episternum and sends dorsally a long arm in front of the pleural wing process similar in appearance to the latter. The epimeral paraptera are connected with the humeral angle of the wing, especially with the head of the costa, by tough membrane, so that a contraction of the pronator muscle turns the wing forward upon

the pleural wing process and at the same time depresses its costal edge. (Also called *preparaptera*.) *Écaille axillaire* Chabrier (1820). *Hypoptère* and *paraptère* Audouin (1824). *Appareil de pronation* Amans (1885). *Alarpleure* Verhoeff (1903). *Episternalgelenkplatten* Voss (1905). *Prefulero* Berlese (1906). *First* and *second parapterum* Snodgrass (1908).

Episternum (*Eps*).—The principal pleural plate lying before or below the pleural suture and pleural ridge, in general forming the anterior half of the pleurum. *Episternum* Audouin (1824), Kolbe (1889), Crampton (1909). Anterior plate of *scapularia* in mesothorax, of *parapleura* in metathorax, Kirby and Spence (1826). *Première iliaque* in mesothorax, *première ischion* in metathorax, Straus-Dürckheim (1828). *Antepleuron* Amans (1885). *Coxopleure* Verhoeff (1903).

Femur (*F*).—The third segment of the leg. *Femur* Fabricius (1778). *Humerus* in prothorax, *femur* in meso- and metathorax, Kirby and Spence (1826). *Cuisse* Straus-Dürckheim (1828).

First axillary (*1, 1Ax, transverse shading*).—The first articular sclerite of the wing base, hinging upon the anterior notal wing process, and specially connected with the base of the subcostal vein of the wing. In rare cases it is divided into two. *Grand huméral* of front wing, *scutellaire* of hind wing, Jurine (1820). *Humerus* Chabrier (1820). *Preepaulière* of elytrum, *axillaire antérieure* of hind wing, Straus-Dürckheim (1828). *Parapteron* Newport (1839). *Sigmoïde* Amans (1885), Petri (1899). *Dens* Lowne (1892). *Vordere* and *mittlere Tergalplatten* Voss (1905). First sclerite of *proptero* Berlese (1906).

Fourth axillary (*4, 4Ax, transverse shading*).—The fourth articular sclerite of the wing base, articulating with the posterior notal wing process mesially and with the third axillary distally. Usually this sclerite is absent, occurring principally in Orthoptera and Hymenoptera. *Naviculaire* Jurine (1820). *Hintere tergalplatte* Voss (1905). Not the *quatrième axillaire* of Straus-Dürckheim (1828).

Frenulum (*Fr*).—A strong spine or bunch of bristles borne by the humeral angle of the hind wing on the base of the costa (204) in most Lepidoptera. By catching in a hook on the under surface of the fore wing it serves to lock the two together. It is absent in those forms provided with a jugum. *Tendo* Kirby and Spence (1826).

Furca (*Fc*).—The biramous apodemes of the thoracic sterna. Sometimes the two arms have separate bases. They are usually attached by short muscles or ligaments to the arms of the pleural ridges. (See *entosternum*.) *Entosternum* Chabrier (1820), Amans (1885). *Entothorax* Audouin (1824). *Antefurca, medifurca,* and *postfurca* Kirby and Spence (1826). *Episterne* Straus-Dürckheim (1828). *Apophysen* Kolbe (1889), Voss (1905).

Gonapophyses (*Gon.*)—The chitinous processes of the eighth and ninth abdominal sterna which form the ovipositor or sting. Two arise from the eighth segment and four from the ninth. *Gonapophyses* Huxley (1878).

Gula (*Gu*).—The throat region, specifically a plate forming the posterior part of the floor of the head in Neuroptera and Coleoptera, bridging the space between the genæ and supporting the labium. Probably derived from the sternum of the microthorax. *Jugulum* and *gula* Kirby and Spence (1826). *Pièce basilaire* Straus-Dürckheim (1828), Lacordaire (1834). *Gula* Newport (1839).

Halter (*Hl*).—The balancer-like representative of the wing in the metathorax of Diptera. It is wing like in pupæ of Tipulidæ (173, W_3). *Halter* Fabricius (1778).

Head (*H*).—Formed of the first five or six embryonic metameres consolidated, with the fused appendages of the next or microthoracic segment attached and forming the labium.

Intersegmental membrane (*Mb*).—The membranous area between two segments. Where phragmæ are present the membrane extends from the dorsal edge of the posterior lamella of the preceding phragma to the dorsal edge of the anterior lamella of the following phragma.

Jugum (*Ju*).—The lobe at the base of the fore wing in the lower Lepidoptera serving to lock the wings together during flight. The jugum is strengthened by the third anal vein (202) and is, hence, not homologous with the alula of Diptera and Coleoptera. *Pterygium* Kirby and Spence (1826).

Katopleure (*Peps*).—See *Preepisternum*.

Lateral notal emargination (*Em*).—A deep notch on the lateral edges of the meso- and metanota between the notal wing processes.

Media (*M*).—The fourth principal vein of the wing.

Median notal groove (*G*).—The longitudinal median groove of the metanotum in Euplexoptera and Coleoptera. *Goutière médiéne* Straus-Dürckheim (1828).

Median plates of the wing base (*m*).—The variable plates in the median region of the base of the wing, associated with the bases of the median and cubital veins. *Rétro-mèdian* Amans (1885). *Vermittelungsplatte* and *vordere Analgelenkplatte* Voss (1905).

Median segment (*IT*).—The "segment médiaire" of Latreille (1821), or the first abdominal segment in Hymenoptera, which is transferred to the thorax and solidly fused with it. It always bears the first abdominal spiracles. *Segment médiaire* Latreille (1821). *Propodeon* Newman (1833).

Mesothorax (*Mes*).—The second thoracic segment. *Segment alaire anterieur* Chabrier (1820). *Mesothorax* Audouin (1824). *First segment of alitruncus* Kirby and Spence (1826). *Prothorax* Straus-Dürckheim (1828).

Metamere.—Any one of the primitive segments of an embryo.

Metathorax (*Met*).—The third thoracic segment. It is sometimes confused with the first abdominal segment in Diptera, and has this segment incorporated into it in the Hymenoptera. *Segment alaire posterieur* Chabrier (1820). *Metathorax* Audouin (1824), Straus-Dürckheim (1828). *Second segment of alitruncus* Kirby and Spence (1826).

Microthorax (*Mi*).—The body of the neck segment. Its sclerites form the cervical sclerites of the neck and probably the gular plate of the head. Its appendages are transferred to the head and fuse to form the labium. *Microthorax* Verhoeff (1902). *Collo* Berlese (1906). *Cervicum* Crampton (1909).

Muscle disk (*MD*).—Any disk-like or cup-shaped apodeme, usually stalked, forming the attachment or insertion of a muscle.

Notal wing processes (*ANP, PNP*).—The anterior and posterior lateral processes of the notum to which are articulated the first and fourth axillaries, or first and third when the fourth is absent. (See *Anterior notal wing process* and *Posterior notal wing process*.)

Notum (*N*).—This term is restricted in this paper to the anterior or wing-bearing plate of the tergum in the meso- and metathorax, the name *postnotum* or *pseudonotum* being given to the secondary posterior plate of the back. Where the latter is absent, as it is in all the other body segments and in all the segments of nymphs and of adult Orthoptera, the notum is the entire tergum.

Paraptera (*P, 1 P, 2 P, 3 P, 4 P*).—The small pleural plates at the base of the wing, typically two before the pleural wing process and two behind it. The former are the *preparaptera* or *episternal paraptera* (which see); the latter are the *postparaptera* or *epimeral paraptera* (which see). *Paraptère* Audouin (1824). *Pleural gelenkplatten* Voss (1905).

Patagium.—The patagia are two vertically elevated lobes of the pronotum in many Lepidoptera. They vary from thick swellings to flat plates. They should not be confused with the tegulæ of the meso-thorax, which are also highly developed in the Lepidoptera. *Patagium* Kirby and Spence (1826).

Pectus.—A term used by the earlier entomologists to designate the ventral and pleural surfaces together of any thoracic segment. *Pectus* Fabricius (1778), Audouin (1824), Kirby and Spence (1826). *Conque pectorale* Chabrier (1820).

Peritreme (*Pt*).—The small plate sometimes surrounding a spiracle. *Péritrème* Audouin (1824).

Phragma (*Ph*).—The vertical or oblique plate depending from the anterior or posterior edge of any tergum. A phragma is really a chitinized inflexion of the intersegmental membrane and, hence, is always composed of two lamellæ, though these are closely appressed

or fused into one plate. An anterior phragma on any segment is a *prephragma* (*Aph*) and a posterior phragma a *postphragma* (*Pph*). A tergum may be provided with both, but the postphragma is nearly always the larger. When a pseudonotum is present it carries the postphragma. (See *Prephragma* and *Postphragma*.) *Phragma* Kirby and Spence (1826), Packard (1898).

Pleural arm (*PA*).—The arm of the pleural ridge present in some form in most insects and usually connected with the corresponding arm of the sternal furca of the same segment. *Apodemzinken* Voss (1905). *Processo pleurale* Berlese (1906). *Adfurcal process* Crampton (1909).

Pleural coxal process (*CxP*).—The condyle at the lower end of the pleural ridge to which the coxa is articulated. Absent in only a few cases, though often hidden by overlapping extensions of the pleurites. *Apophyse pedio-pleurale* Amans (1888). *Coxalgelenkkopf* Voss (1905). *Condilo pedifero* Berlese (1906). *Coxal process* Snodgrass (1908), Crampton (1909).

Pleural ridge (*PR*).—The internal ridge developed along the pleural suture between the episternum and epimerum. Dorsally it forms the *pleural wing process* (*WP*) and ventrally the *pleural coxal process* (*CxP*). Internally it carries the *pleural arm* (*PA*). All of these parts together may be regarded as constituting the *entopleurum*. *Entopleuron* Amans (1885), Crampton (1909). *Pleuralleiste* Voss (1905). *Apodem* Kolbe (1889). *Pleurale* Berlese (1906).

Pleural suture (*PS*).—The external suture between the episternum and epimerum, extending from the wing process to the coxal process. *Pleuralfurche* Voss (1905). *Pleural suture* Snodgrass (1908), Crampton (1909).

Pleural wing process (*WP*).—The process formed by the upper end of the pleural ridge, formed of elements derived from the episternum and epimerum, which forms the pleural support of the wing, the latter articulating with it by means of the second axillary sclerite. *L'appui de l'aile* or *clavicula thorachique* Chabrier (1820). *Alifère* Straus-Dürckheim (1828). *Clavicula alæ* Lendenfeld (1881). *Apophyse alifère* and *pivot fixe* or *mèdian* Amans (1885). *Ascending process* Lowne (1892). *Pleuralgelenkkopf* Voss (1905). *Fulcro alifero* Berlese (1906). *Alar process* Crampton (1909).

Pleurites (*Eps, Epm, Peps, P, Tn*).—The sclerites constituting any pleurum. (Frequently used as synonymous with *pleura*.)

Pleurum (*Pl*).—The morphological lateral surface of any segment—the chitinous area on the side between the tergum and sternum. *Clavicules anteriores* in mesothorax, *plaques fulcrales* in metathorax Chabrier (1820). *Pleura* Audouin (1824). *Pleuron* Amans (1885), Crampton (1909). *Pleurum* Comstock and Kellogg (1902).

Posterior notal ridge (PNR).—The posterior marginal thickening of the notum, generally turned downward and forward in adult insects so that it comes to lie in front of the resulting posterior edge, the latter thus often forming a large posterior reduplication.

Posterior notal wing process (PNP).—The posterior lateral process on each side of the notum which articulates with the wing by the fourth axillary or by the third when the fourth is absent. It is sometimes a long arm, and in a few cases is absent as a distinct process. *Apophyse styloïde* Chabrier (1820). *Apophyse de quatrième axillaire* Straus-Dürckheim (1828). *Great alar apophysis* Lowne (1892). *Mesocondilo* Berlese (1906).

Posterior phragma (Pph).—See *Postphragma.*

Posterior reduplication of the notum (Rd).—The posterior edge of the notum folded downward and forward upon itself, leaving a free margin overlapping the succeeding parts. Often very large, as in the prothorax of Acridiidæ and mesothorax of Hemiptera.

Postnotum (PN).—See *Pseudonotum.*

Postparaptera (3P, 4P).—See *Epimeral paraptera.*

Postphragma (Pph).—The posterior phragma of any segment. Specially developed in the meso- and metatergum, where it is carried by the pseudonotum. It is developed to the greatest extent in the mesothorax of the Diptera, where it forms the partition separating the thoracic cavity from the abdominal. (See *Phragma.*) Internal part of the *costal* of Chabrier (1820). *Phragma* of prothorax, *metaphragma* of metathorax, Kirby and Spence (1826). *Postscutellum internal* Mac Leay (1830). Internal part of *subpostdorsum* of Amans (1885). Internal part of *phragma* of Kolbe (1889). *Metaphragma* and, in some cases, *mesophragma* Berlese (1906).

Postscutellum (PN).—See *Pseudonotum.*

Poststernellum (Psl).—The fourth division of the sternum, if four parts ever occur. *Poststernum* (apparently intended for *poststernellum*) Mac Leay (1830). *Poststernellum* Comstock and Kochi (1902).

Preepisternum (Peps).—A pleural plate of some lower insects, especially the Orthoptera and Euplexoptera, lying before the episternum, or below it when the pleural suture is horizontal. *Katopleure* (except in Blattidæ) Verhoeff (1903), Snodgrass (1908). *Episternal laterale* Crampton (1909).

Preparaptera (P, 1P, 2P).—See *Episternal paraptera.*

Prephragma (Aph).—The anterior phragma of any tergum, carried by the anterior notal ridge. *Prædorum* or *cloison cervicale* Chabrier (1820). *Prophragma* of mesothorax, *mesophragma* of metathorax, Kirby and Spence (1826). *Limbe de l'eccusson* in mesothorax, *diaphragme* in metathorax, Straus-Dürckheim (1828). *Præs-*

cutum internal Mac Leay (1830). Internal part of *antedorsum* of Amans (1885). *Proterophragma* in mesothorax, *deutophragma* in metathorax, Voss (1905). *Prophragma* in mesothorax, *mesophragma* in some cases in metathorax, Berlese (1906).

Prescutum (*Psc*).—The first subdivision of the notum. Not homologous in all orders. *Præscutum* Andouin (1824), Mac Leay (1830), Newport (1839), Kolbe (1889), Voss (1905), Crampton (1909). Exposed part of *prophragma* Kirby and Spence (1826). Exposed part of *antédorsum* Amans (1885). *Protergite* Berlese (1906).

Presternum (*Ps*).—The anterior division of the sternum. Sometimes it is a transverse plate, but it is frequently reduced to two small sclerites lying before the sternum proper or at the anterior angles of it. *Præsternum* Mac Leay (1830), Comstock and Kochi (1902). *Antésternum* Amans (1885). *Vorplatte* Verhoeff (1903). *Coxosternum* Börner (1904), Voss (1905). *Acrosternite* Berlese (1906). *Accessory sternal plates* Snodgrass (1908). *Præsternum* and *Sternal laterale* Crampton (1909).

Pronator disk (*PD*).—The large disk often carried internally by one· of the episternal parapetera for the insertion of the pronator muscle. In a few cases it is attached to the adjacent part of the episternum. *Cupule du muscle pectorali-axillaire* Chabrier (1820). *Grand cupule de l'aile* Straus-Dürckheim (1828). *Grand cupule* (of pronator apparatus) Amans (1885). *Cupula* also *processo pleurale* (the second a mistaken identification with pleural arm) Berles (1906).

Pronator muscle.—The large muscle inserted upon the pronator disk of the preparapetera. *Muscle pectorale-axillaire* Chabrier (1820).

Prothorax (*Pro.*).—The first segment of the thorax back of the microthoracic or neck segment. *Prothorax* Chabrier (1820), Audouin (1824). *Manitruncus* Kirby and Spence (1826). *Corselet* Straus-Dürckheim (1828).

Pseudonotum (*PN*).—The *postnotum*, or second tergal plate of the meso- and metathorax of nearly all adult insects except the Orthoptera, the *notum* constituting the first or wing-bearing plate of the tergum. The pseudonotum is a secondary plate, being absent in all nymphs and in the pupæ of Neuroptera and Coleoptera at least. Best developed in the higher orders and nearly always connected laterally with the epimera. It carries the postphragma. *Cloison costale* or simply *costal* Chabrier (1820). *Postscutellum* Audouin (1824), Newport (1839), Kolbe (1889), Crampton (1909). *Postfrænum* (?) in metathorax, Kirby and Spence (1826). *Tergum* in metathorax, Straus-Dürckheim (1828). *Subpostdorsum*, including postphragma, Amans (1885). *Metaphragma*, including true postphragma, Kolbe (1889). *Pseudonotum* (in Dermaptera) Verhoeff

(1903), (as a general term) Snodgrass (1908). *Acrotergite* of following tergum, in most cases, Berlese (1906).

Radius (R).—The third principal vein of the wing, associated at its base with the second axillary.

Sclerite.—Any one of the chitinous plates of the body wall or of the appendages.

Scutellum (Scl).—The third division of the notum, often forming a prominent shield-shaped or triangular elevation. Not homologous in all orders. *Scutellum* (the raised part of dorsum between wings) Fabricius (1778). *Postdorsum* or *podorsum* Chabrier (1820), Amans (1885). *Scutellum* Audouin (1824), Newport (1839), Kolbe (1889), Crampton (1909). *Scutellum* (median) and *frænum* (lateral) in mesothorax, *postscutellum* in metathorax, Kirby and Spence (1826). *Postscutum* Voss (1905). *Metatergite* Berlese (1906).

Scutum (Sct).—The second division of the notum. Not homologous in all orders. *Écusson* and *dorsum* Chabrier (1820). *Scutum* Audouin (1824) Mac Leay (1830), Newport (1839), Kolbe (1889), Voss (1905), Crampton (1909). *Dorsolum* in mesothorax, *postdorsolum* in metathorax, Kirby and Spence (1826). *Dorsum* Amans (1885). *Mesotergite* Berlese (1906).

Second axillary (2, 2 Ax, oblique shading in unbroken lines).—The pivotal sclerite of the wing base, resting upon the pleural wing process, articulating with the first axillary mesially and usually with the base of the radius distally. *Petit huméral* in front wing, *diadémal* in hind wing, Jurine (1820). *Omoplate* Chabrier (1820). *Epaulière anteriéure* of elytron, *seconde axillaire* of hind wing, Straus-Dürckheim (1828). *Submédian* Amans (1885), Petri (1899). *Unguiculus* Lowne (1892). *Mittlegelenkplatte* Voss (1905). Posterior sclerite of *proptero* Berlese (1906).

Segment.—Any one of the divisions of the head and body corresponding with the primitive metameres. The head is a combination of segments. Also any one of the joints of the legs or antennæ.

Segment médiaire (IT in Hymenoptera).—See *Median segment.*

Spiracle (Sp).—Any one of the breathing apertures of the tracheal system, situated, in adult insects, along the sides of the body. In the thorax there are two on each side, one in the membrane between the pro- and the mesothorax and the other between the meso- and the metathorax. The first is commonly regarded as prothoracic and the second as metathoracic. But Börner (1903) regards the first as mesothoracic and the second as metathoracic, because, as he says, it is a well-known fact that the spiracles are developed in front of the sclerites of the segments to which they belong. In *Japyx solifugus* there are apparently four pairs of thoracic spiracles, but Börner regards the second two as being abdominal spiracles moved forward. *Stigma* Audouin (1824), Newport (1839). *Spiracle* Kirby and Spence (1826).

Sternellum (*Sl*).—The third division of the sternum. *Sternellum* MacLeay (1830), Comstock and Kochi 1902. *Poststernum* Amans (1885).

Sternites (*Ps, S, Sl*).—All the sclerites of any sternum. (Generally used as synonymous with *sterna*.)

Sternum (*S*).—The entire ventral surface of any segment corresponding with the *tergum*, or also, specifically, the principal or second sternal sclerite. *Sternum* Audouin (1824).

Subcosta (*Sc*).—The second principal vein of the wing, associated at its base with the first axillary.

Supraepimerum.—A dorsal subdivision of the epimerum in the meso- and metathorax of Coleoptera (*epm*), often entirely separated in the metathorax. *Parapleure* Kolbe (1889), *Postparapterum* Snodgrass (1908).

Tarsus.—The foot of insects, composed of five, or fewer, small joints, the last bearing the claws. *Tarsus* Fabricius (1778) *Manus* of front leg, *tarsus* of middle and hind legs, Kirby and Spence (1826).

Tegula (*Tg*).—The scale-like plate overlapping the front angle of the base of the wing in Lepidoptera, Hymenoptera, and Diptera, and its pad-like representative at the base of the wing in other orders. The tegulæ of the front wings of Lepidoptera are specially large and are carried by special *tegular plates* (*tg*) of the notum. These, in turn, are supported by special internal *tegular arms* (*tg A*) from the bases of the pleural wing processes. *Cuilleron* Jurine (1820). *Tegula* Kirby and Spence (1826). *Parapteron* MacLeay (1830).

Tergites (*Psc, Sct, Scl, PN*).—The sclerites composing the tergum of any segment. (Generally used as synonomous with *terga*.)

Tergum (*T*).—The entire chitinization of the dorsum of any segment. (See *Notum* and *Pseudonotum.*) *Tergum* Audouin (1824), MacLeay (1830). *Notum* Burmeister (1832), Newport (1839). *Prothorax, mesothorax* and *metathorax* (thoracic terga) Kirby and Spence (1826). *Bouchier* (protergum), écusson (mesotergum), *clypeus* and *tergum* (metatergum) Straus-Dürckheim (1828).

Third axillary (*3, 3 Ax, longitudinal shading*).—The sclerite of the wing base associated with the bases of the anal veins and affording insertion for the muscles which fold the anal area of the wing. Anteriorly it articulates with a process of the second axillary, and mesally with the posterior notal wing process except when the fourth axillary is present, which intervenes between the third and the wing process. The muscle insertion is on the mesal side of the axis of the sclerite so that by its contraction the sclerite revolves and folds the attached anal part of the wing. *Petit cubital* of front wing, *fourchu* of hind wing, Jurine (1820). *Onguiculus* Chabrier (1820). *Epaulière posterieure* of elytrum, *quatrième axillaire* of hind wing, Straus-Dürckheim (1828). *Terminal* Amans (1885), Petri (1899). *Meta-*

pterygium and *deltoid* Lowne (1902). *Analwurzelplatte* and *hintere Analgelenkplatte* Voss (1905). *Mesoptero* Berlese (1906).

Thorax.—The middle division of an insect, composed of three segments—the *prothorax*, the *mesothorax*, and the *metathorax*. The microthorax is the segment of the neck sclerites and the labium, and there is, hence, no reason for counting it as a thoracic segment. The primitive thoracic region may have been composed of a greater number of segments than three, but the extra ones have disappeared or remained only as small intersegmental plates in some of the Aptera. *Truncus* Fabricius (1778), Kirby and Spence (1826). *Thorax* Chabrier (1820), Audouin (1824), *Corselet* (prothorax) and *thorax* (meso- and metathorax) Straus-Dürckheim (1828).

Tibia (*Tb*).—The fourth joint of the leg, between the femur and the tarsus. *Tibia* Fabricius (1778). *Cubitus* of front leg, *tibia* of middle and hind legs, Kirby and Spence (1826). *Jambe* Straus-Dürckheim (1828).

Trochanter (*Tr*).—The second joint of the leg, between the coxa and the femur. It consists of two subjoints in some Hymenoptera. *Scapula* of front leg, *trochanter* of middle and hind legs, Kirby and Spence (1826). *Trochanter* Straus-Dürckheim (1828).

Trochantin (*Tn*).—The plate of the thoracic wall anterior to the base of the leg, articulating above with the episternum and below with the ventral rim of the coxa. It is large and prominent in most of the lower insects, but is frequently absent or fused with the sternum or episternum in the higher orders. It is situated on the side of the thorax, but may be a sternal plate in its origin. The coxa is normally articulated above to the coxal process (*CxP*) of the pleurum, and below to the coxal process of the trochantin (*TnC*). Only in rare cases is it articulated to the sternum, as in the nymphs of Odonata. *Trochantin* Audouin (1824), Verhoeff (1903), Snodgrass (1908), Crampton (1909). *Rotule* Straus-Dürckheim (1828). *Trochantinus* Kolbe (1889). Not the *trochantine* of Packard (1898). *First antecoxal piece* (Blattidæ) Comstock and Kochi (1902). *Präcoxalplatte* (*Trochantin*) Voss (1905). *Trochantino* Berlese (1906).

Vena dividens (*D*).—The secondary vein developed in the first anal fold of the wing of some insects, especially in Orthoptera.

Venter.—The entire morphological ventral surface of the insect or of any part or segment, corresponding with the *dorsum* above. The *sterna* are the segmental chitinizations of the venter, and the *sternites* (as used in this paper) the sclerites of any sternum.

Wings (W$_2$, W$_3$).—The organs of flight. In the nymphs of insects with incomplete metamorphosis the wings appear to be extensions of the lateral edges of the meso- and metathoracic terga. In adults they

appear to be outgrowths of the body wall from the tergo-pleural sutures, and are articulated to the wing processes of the tergum and pleurum by the *axillary sclerites*.

Wing Process (WP).— See *Pleural wing process*.

IX. BIBLIOGRAPHY.

1778. FABRICIUS, J. C., Philosophia Entomoligica.

1820. CHABRIER, J., Essai sur le vol des insectes.—Mém. du Mus. d'Hist. Nat., VI, 1820, pp. 410–472, pls. XVIII–XXI.

1820. JURINE, L., Observationes sur lesailes des Hymenopteres.—Mem. Reale Accad. Sci. Torino, XXIV, 1820, pp. 177–214, pls. III–VIII.

1821. LATREILLE, P. A., De quelques appendices particuliers du thorax de divers insectes.—Mem. du. Mus. d'Hist. Nat., VII, 1821, pp. 1–21.

1824. AUDOUIN, V., Recherches anatomique sur le thorax des animaux articulés et celui des insectes hexapodes en particulier.—Ann. des Sci. Nat., I, 1824, pp. 97–135, 416–432, pl. VIII.

1826. KIRBY, W. and SPENCE, W., An introduction to entomology, III, London, 1826.

1828. STRAUS-DÜRCKHEIM, H., Considerationes générales sur l'anatomie comparée des animaux articulés, 435 pp., 19 pls. Published by the Royal Institute of France, 1828 (contains detailed description of anatomy of *Melolontha vulgaris*).

1830. MAC LEAY, W. S., Explanation of the comparative anatomy of the thorax of winged insects, with a review of the present state of the nomenclature of its parts.—Zool. Journ., V, 1830, pp. 145–179, pls. V, VI.

1830. WESTWOOD, J. O., On the thorax of insects.—Zool. Journ., V, 1830, pp. 326–328. (Principally a review of Mac Leay, 1830.)

1832. BURMEISTER, H., Handbuch der Entomologie, I, pls. I–XVI, Berlin, 1832.

1833. NEWMAN, E., Osteology, or external anatomy of insects: I. On the primary parts of insects.—Ent. Mag., I, 1833, pp. 394–413. II. On the head of insects.—Idem, II, 1835, pp. 60–92, pls. VI, VII.

1834. LACORDAIRE, T., Introduction à l'entomologie, I, Paris, 1834.

1838. WESTWOOD, J. O., On the comparative structure of the scutellum and other terminal dorsal parts of the thorax of winged insects.—Ent. Mag., V, 1838, pp. 459–469.

1839. NEWPORT, G., Insecta.—Todd's Cyclopædia of Anatomy and Physiology, II, pp. 853–994, figs. 329–439. London, 1839.

1866. PACKARD, A. S., JR., Observations on the development and position of the Hymenoptera, with notes on the morphology of insects.—Proc. Boston Soc. Nat. Hist., X, 1866, pp. 279–295, 4 figs.

1870. BÜTSCHLI, O., Zur Entwicklungsgeschichte der Biene.—Zeitschr. f. Wiss. Zool., XX, 1870, pp. 519–564.

1878. HUXLEY, T. H., A manual of the anatomy of invertebrated animals, London, 1878.

1881. HAMMOND, A., Thorax of the blow-fly.—Journ. Linn. Soc. London, XV, 1881, pp. 9–31.

1881. LENDENFELD, R., Der Flug der Libellulen. Ein Beitrag zur Anatomie und Physiologie der Flugorgane der Insekten.—Sitz. der k. Akad. der Wiss. Wien, Math-Nat. Classe, LXXXIII, I. Abth, 1881, pp. 289–376, pls. I–VII.

1882. BRAUER, F., Ueber das segment médiaire Latreille's.—Sitz. der k. Akad. der Wiss. Wien, Math-Nat. Classe, LXXXV, I. Abth., 1882, pp. 218–241, pls. I–III.

1883. Gosch, C. C. A., on Latreille's theory of "Le Segment médiaire;" a contribution to the history of entomologie.—Kröyer's Nat. Tidsskrift (3), XIII, 1883, pp. 475–531.

1885. Amans, P. C., Comparisons des organes du vol dans la série animale.—Ann. Sci. Nat., Sér. 6, Zool., XIX, 1885, pp. 9–222, pls. I–VIII.

1887. Viallanes, H., Études histologique et morphologique sur les centres nerveux et les organes des sens dans animaux articulés.—Ann. Sci. Nat., Sér. 7, Zool., IV, pp. 1–120, pls. 1–6.

1889. Kolbe, H. J., Einführung in die Kenntnis der Insekten, Berlin, 1889.

1890. Patten, W., On the origin of vertebrates from Arachnids.—Quart. Journ. Micr. Sci., XXXI, 1890, pp. 317–378.

1892. Lowne, B. T., The anatomy, physiology, morphology, and development of the blow-fly, 2 vols., London, 1890–1895. (Thorax in vol. I, pp. 154–209.)

1893. Banks, N., Notes on the mouthparts and thorax of insects and chilopods.—Amer. Nat., XXVII, 1893, pp. 400, 401.

1893. Hansen, H. J., Zur Morphologie der Gliedmassen und Mundtheile bei Crustaceen und Insekten.—Zool. Anz., XVI, 1893, pp. 193–198, 201–212.

1893. Wheeler, W. M., A contribution to insect embryology.—Journ. of Morphology, VIII, 1893, pp. 1–160, pls. 1–6.

1895. Heymons, R., Segmentierung des Insektenkörpers.—Anhang zu den Abh. K. Akad. Wiss. Berlin, 1895, 39 pp., 1 pl.

1897. Bengtsson, S., Studier öfer Insektlarven, I. Till kännedomen om Larven of Phalacrocera replicata (Lin.).—Akad. Afhandl. Lunds Universitet Arsskrift, XXXIII, 1897, pp. 1–117, pls. I–IV.

1897. Uzel, H., Beitrage zur Entwicklungsgeschichte von Campodea staphylinus Westr.—Zool. Anz., XX, 1897, pp. 125–237.

1898. Claypole, A. M., The embryology and oögenesis of Anurida maritima.—Journ. Morph., XIV, 1898, pp. 219–300.

1898. Packard, A. S., A text-book of Entomology, New York, 1898.

1899. Comstock, J. H., and Needham, J. G., The wings of insects.—Numerous papers in Amer. Nat., XXXII, 1898, and XXXIII, 1899.

1899. Folsom, J. W., The segmentation of the insect head.—Psyche, VIII, 1899, pp. 391–394.

1899. Janet, C., Essai sur la constitution morphologique de la tête de l'insect, 74 pp., 2 figs., 7 pls., Paris, 1899.

1899. Petri, L., I musculi delle ali nei Ditteri e negli Imenotteri.—Bull. Soc. Ent. Italiana, XXXI, 1899, pp. 3–42, pls. I–III.

1900. Folsom, J. W., The development of the mouth parts of Anurida maritima Guer.—Bull. Mus. Comp. Zoöl., XXXVI, No. 5, 1900, pp. 87–157, pls. 1–8.

1900. Janet, C., Recherches sur l'anatomie de la fourmi et essai sur la constitution morphologique de la tête de l'insecte, 205 pp., 13 pls., Paris, 1900.

1900. Walton, L. B., The basal segment of the Hexapod leg.—Amer. Nat., XXXIV, 1900, pp. 267–274.

1902. Comstock, J. H. and Kellogg, V. L., Elements of insect anatomy, 4th ed., Ithaca, N. Y., 1902.

1902. Comstock, J. H. and Kochi, C., The skeleton of the head of insects.—Amer. Nat., XXXVI, 1902, pp. 13–45, 29 figs.

1902. Silvestri, F., Einige Bemerkungen über den sogenannten mikrothorax der insekten.—Zool. Anz., XXV, 1902, pp. 619–620.

1902. Verhoeff, K. W., Ueber Dermapteren I. Aufsatz: Versuch eines neuen natürlichen Systems auf vergleichend-morphologischer Grundlage und den Mikrothorax der Insekten.—Zool. Anz., XXV, 1902, pp. 181–208.

1903. BÖRNER, C., Kritische Bemerkung, über einige vergleichend-morphologische Untersuchungen K. W. Verhoeff's.—Zool. Anz., XXVI, 1903, pp. 290–315, 11 figs.

1903. SNODGRASS, R. E., The anatomy of the Carolina locust (*Dissosteira carolina* Linn.).—Washington State Agricultural College, Pullman, Washington, 1903.

1903. VERHOEFF, K. W., Beiträge zur vergleichenden Morphologie des Thorax der Insekten mit Berüchsichtigung der Chilopoden.—Nova Acta. Abh. der k. Leop.-Car. Deut. Akad. der Naturf., LXXXI, 1903, pp. 63–109, pls. VII–XIII.

1903a. VERHOEFF, K. W., Ueber die Endsegmente des Körpers der Chilopoden, Dermapteren und Japygiden und zur Systematik von *Japyx.*—Nova Acta. Abh. der k. Leop.-Car. Deut. Akad. der Naturf., LXXXI, 1903, pp. 257–297, pls. XVIII, XIX.

1903b. VERHOEFF, K. W., Ueber die Nerven des Metacephalsegments und die Insektenordnung Oöthecaria.—Zool. Anz., XXVI, 1903, pp. 20–31, 9 figs.

1903c. VERHOEFF, K. W., Ueber die Interkalarsegmente der Chilopoden mit Berüchsichtigung der zwischensegmente der Insekten.—Arch. Nat., LXIX (1), 1903, pp. 427–441, pl. XXIII.

1903. WALTON, L. B., The arrangement of the segmental muscles in the Geophilidæ and its bearing upon the double nature of the segment in the Hexapoda and Chilopoda.—Science, XVII, 1903, p. 485.

1904. BANKS, N., Notes on the structure of the thorax and maxillæ in insects.—Proc. Ent. Soc. Wash., VI, 1904, pp. 149–153, pl. I.

1904. BÖRNER, C., Zur Systematik der Hexapoden.—Zool. Anz., XXVII, 1904, pp. 511–533.

1904. HOLMGREN, N., Zur Morphologie des Insektenkopfes. I. Zum metameren Aufbau des Kopfes der *Chironomus*-Larve.—Zeit. für Wiss. Zool., LXXVI, 1904, pp. 439–477, pls. XXVII, XXVIII. II. Einiges über die Reduction des Kopfes der Dipterenlarven.—Zool. Anz., XXVII, 1904, pp. 343–355.

1904. RILEY, W. A., The embryological development of the skeleton of the head of *Blatta.*—Amer. Nat., XXXVIII, 1904, pp. 777–810, 12 figs.

1904. VERHOEFF, K. W., Zur vergleichenden Morphologie und Systematik der Embiiden : zugleich 3, Beiträge zur Kenntnis des Thorax der Insekten.—Nova Acta. Abh. der k. Leop.-Car. Deut. Akad. der Naturf., LXXXII, 1904, pp. 141–205, pls. IV–VII.

1904a. VERHOEFF, K. W., Zur vergleichenden Morphologie und Systematik der Japygiden, zugleich 2, Aufsatz über den Thorax der Insekten.—Arch. Naturg., LXX (1), 1904, pp. 63–114, pls. IV–VI.

1905. BENGTSSON, S., Zur Morphologie des Insektenkopfes.—Zool. Anz., XXIX, 1905, pp. 457–476.

1905. HEYMONS, R., Review of Verhoeff (1905) on the morphology of the insect head.—Zool Centr., XII, 1905, pp. 539–543.

1905. IMHOF, O. E., Zur Kenntnis des Baues der Insektenflügel insbesondere bei Cicadiden.—Zeit. f. Wiss. Zool., 1905, pp. 211–223.

1905. VERHOEFF, K. W., Ueber vergleichende Morphologie des Kopfes niederer Insekten mit besonderer Berücksichtigung der Dermapteren und Thysanuren nebst biologische-physiologische Beiträgen.—Nova Acta. Abh. der k. Leop.-Car. Deut. Akad. der Naturf., LXXXIV, 1905, pp. 1–144, pls. I–VIII.

1905. VOSS, F., Ueber den Thorax von *Gryllus domesticus*, mit besonderer Berücksichtigung des Flügelgelenks und dessen Bewegung.—Zeit. F. Wiss. Zool., LXXVIII, 1905, pp. 268–521, 654–759, pls. XV, XVI, XXIV.

1906. BERLESE, A., Gli Insetti, loro organazzizione sviluppo, abitudini e rapporti coll'uomo.—Published by the Società Editrice Libraria, Milan, 1906.

1907. HEWETT, C. G., The structure, development, and bionomics of the house fly.—Quart. Journ. Micr. Sci., LI, 1907, pp. 395–448, pls. XXII–XXV.

1907. HOLMGREN, N., Zur Morphologie des Insektenkopfes. III. Das "Endolabialmetamer" der Phalocrocera-Larve.—Zool. Anz., XXXII, 1907, pp. 73–97, 9 figs.

1908. CRAMPTON, G. C., Ein Beitrag zur Homologie der Thorakal-Sclerite der Insekten.—Inaug. Diss., Berlin, 1908.

1908. DESGUIN, E., La composition segmentaire du thorax des insectes.—Ann. de la Soc. Ento. de Belgique, LII (3), 1908, pp. 113–126, pls. I, II.

1908. SNODGRASS, R. E., A comparative study of the thorax in Orthoptera, Euplexoptera, and Coleoptera.—Proc. Ent. Soc. Washington, IX, 1908, pp. 95–108, pls. II–V.

1909. CRAMPTON, G. C., A contribution to the comparative morphologie of the thoracic sclerites of insects.—Proc. Acad. Nat. Sci. Philad., 1909, pp. 3–54, pls. I–III, 21 text figs.

1909. SNODGRASS, R. E., The thoracic tergum of insects.—Ent. News, March, 1909, pp. 97–104, pl. VI.

X. EXPLANATION OF THE PLATES.

(Drawings by the writer.)

Abbreviations.

A, anal vein or veins.

AF, anal fold of the wing.

Al, alula.

ANP, anterior notal wing process.

ANR, anterior notal ridge.

anr, line on surface of notum formed by ANR.

Ap, apodeme.

Aph, anterior phragma or prephragma in each segment.

Au, auditory organ of locust.

1Ax, 2Ax, 3Ax, 4Ax (also *1, 2, 3, 4*), the first, second, third, and fourth axillaries or articular sclerites of the wing base. On plates 64–69 the first and fourth indicated by transverse shading, the second by oblique, the third by longitudinal.

AxC, axillary cord.

AxM, axillary membrane.

C, costa or first vein of wing.

Cr, cercus, appendage of tenth abdominal segment.

Cu, cubitus, or fifth vein of wing.

Cx, coxa.

Cxa, accessory sclerite at base of coxa.

CxC, coxal cavity.

CxP, coxal process.

D, vena dividens.

El, elytrum.

Em, lateral emargination of notum.

Epm, epimerum.

epm, subdivision of epimerum.

Eps, episternum.

eps, subdivision of episternum.

F, femur.

Fc, furca or entosternum.

Fr, frenulum.

G, median groove of notum.

Gu, gula.

H, head, or base of head.

Hl, halter.

IPh, phragma of first abdominal tergum.

IS–XS, first to tenth abdominal sterna.

ISp, IISp, first and second abdominal spiracles.

IT–XT, first to tenth abdominal terga.

Ju, jugum.

M, media or fourth vein of wing.

Mb, intersegmental membrane.

mb, membranous area in prescutum of Coleoptera.

MD, muscle disc.

Mes, mesothorax.

Met, metathorax.

Mi, microthorax.

mi, cervical or microthoracic sclerites.

N, notum.

NA, notal (pseudopleural) internal arm of pronotum of *Melanoplus.*

NCxP, notal (pseudopleural) coxal process of prothorax of *Melanoplus.*

NR, internal notal (pseudopleural) ridge of prothorax of *Melanoplus.*

P, parapterum.

IP, 2P, first and second preparaptera or episternal paraptera.

3P, postparapterum or epimeral parapterum.

PA, pleural arm of the internal pleural ridge.

PD, parapteral or pronator muscle disc.

Peps, preëpisternum.

Ph, phragma.

Pl, plate in pleurum of Chilopoda.

PN, pseudonotum or postnotum (postscutellum).

PNP, posterior notal wing process.

PNR, posterior notal ridge.

p n r, line on the surface of notum formed by PNR.

Pph, posterior phragma or postphragma of each segment.

PR, pleural ridge (pleural apodeme, entopleurum).

PS, pleural suture, between episternum and epimerum forming pleural ridge (*PR*) internally.

Ps, presternum, or presternal plates.

psc, prescutum.

R, radius or third vein of wing.

Rd, posterior reduplication of edge of notum.

S, sternum.

IS–XS, first to tenth abdominal sterna.

Sc, subcosta or second vein of wing.

scl, scutellum.

sct, scutum.

Sl, sternellum.

Sm, submentum.

Sp, spiracle.

1 Sp, 2 Sp, first and second thoracic spiracles.

I Sp, II Sp, first and second abdominal spiracles.

T, tergum.

IT–XT, first to tenth abdominal terga.

1t, subdivision of first abdominal tergum.

Tg, tegula or its rudiment.

tg, tegular plate of Lepidopteran notum carrying the tegula.

tgA, tegular arm of pleural wing process in Lepidoptera supporting tegular plate of notum.

Tn, trochantin.

tn, subdivision of trochantin.

Tna, accessory trochantinal plate.

TnC, trochantinal articulation of coxa.

TnCxP, trochantinal (pseudopleural) coxal process in Plecoptera.

TnR, trochantinal (pseudopleural) ridge in Plecoptera.

TnS, trochantinal (pseudopleural) suture in Plecoptera.

V, entodorsum or V-shaped ridge on undersurface of meso- and metathoracic nota.

v, V-shaped line formed on surface of notum by the entodorsum (*V*) or V-shaped ridge of undersurface.

W, wing.

w, transverse ventral ridge of metanotum in Coleoptera or its line on dorsal surface of notum dividing the scutum into two plates.

WP, wing process of pleurum.

Miscellaneous lettering.

a,   postepimeral strip of pronotum in Odonata (5, 7, 12).

b,   rod connecting prosternum and mesosternum in Odonata (6, 10, 11).

c,   rod connecting parapterum with head of costa in Ephemerida (1, 4).

d,   sternal coxal condyl in nymphs of Odonata (11, 16).

e,   sternal pit or pits marking the location of the furca (10, 11).

f,   posterior arms of the metanotum in Euplexoptera (96).

g,   prothoracic spiracular plates in Odonata attached to mesothorax (18).

h,   anterior arm of pleural wing process in Odonata (18, 19).

i,   points of articulation of pseudonotum (postscutellum) in Coleoptera with epimera (132–137, 139, 140).

j,   small plates yoking mesonotum and metanotum in *Blatella* (38, 40).

k,   coxal condyle of epimerum in *Benacus* (84, 89).

l,   median sternal apodeme of *Phassus* (152).

mi,   individual plates of microthorax.

n,   rod connecting parapterum with wing base in Euplexoptera (mesothorax 90, metathorax 98, 100).

o,   point of insertion of posterior muscle disk of wing in *Cyllene* (140).

p,   small sclerite in prothorax of *Phassus* (152) bearing procoxa.

q,   yoke plates between mesonotum and metanotum in Coleoptera (127, 128, 131).

r,   common base of anal veins fused with end of scutellum in Dytiscus (136, 137).

s,   ridges on under surface of meso- and metanotum in Acridiidæ (54) or lines formed by them on dorsal surface (53).

1t,   anterior subdivision of first abdominal tergum (*IT*) in Acridiidæ (57).

tg,   plate on Lepidopteran notum supporting the tegula (149, 150, 156).

tgA, arm of pleural wing process in Lepidoptera supporting tegular plate (*tg*) of notum (153, 154).

tn,   subdivision of trochantin in Blattidæ (32, 35).

u,   lobe at posterior lateral angles of prescutum in Diptera (175, 180).

v, line on dorsal surface of notum formed by ventral V-shaped ridge, in some
Orthoptera (38, 50), Coleoptera (131, 133, 137, 138), Neuroptera (143),
Lepidoptera (149, 150, 151, 156), Diptera (175, 180).

w, transverse ridge or ridges on under surface of metanotum in Coleoptera
or its line on the dorsal surface, dividing the scutum into two regions
(132–138, 140).

x, y, z. anterior, middle, and posterior transverse external grooves and corre-
sponding internal ridges on pronotum of *Melanoplus* (51, 52). The
middle ridge (NR) takes place of pleural ridge.

Numbering.

1, 2, 3, 4, first axillary (*1 Ax*), second axillary (*2 Ax*), third axillary (*3 Ax*),
and fourth axillary (*4 Ax*) of wing base.

Roman numerals *I–X* designate first to tenth abdominal segments, combined
with letters *T* and *S* indicate terga and sterna of individual segments.

Figures *1, 2,* and *3* placed behind and below an abbreviation refer it to the
prothorax, mesothorax, or metathorax, respectively.

Figures *1, 2, 3,* etc., placed before an abbreviation signify first, second, third,
etc.

Plate 40.

Fig. 1. *Hexagenia bilineata,* mesothorax nad base of wing, lateral.
2. *Hexagenia bilineata,* metathorax and base of wing, lateral.
3. *Hexagenia bilineata,* metatergum.
4. *Hexagenia bilineata,* mesotergum and base of right wing.

Plate 41.

Fig. 5. *Libellula auripennis,* adult, prothorax and microthorax, lateral.
6. *Libellula auripennis,* adult, plates of microthorax (*mi*), prosternum
(*S*) and presternum (*Ps*).
7. *Pachydiplax longipennis,* adult, prothorax, lateral.
8. *Lestes uncatus,* nymph, microthorax and prothorax, lateral.
9. *Lestes uncatus,* adult, microthorax and prothorax, lateral.
10. *Pachydiplax longipennis,* adult, prosternum.
11. *Gomphus brevis,* adult, prosternum.
12. *Gomphus plagiatus,* nymph, microthorax and prothorax, lateral.
13. *Gomphus brevis,* adult, prothorax, lateral.

Plate 42.

Fig. 14. *Gomphus plagiatus,* large nymph, meso- and metathorax, dorsal.
15. *Pachydiplax longipennis,* small nymph, meso- and metanotum and
bases of wings.
16. *Libellula pulchella,* nymph, meso- and metathorax, lateral.
17. *Pachydiplax longipennis,* adult, meso- and metatergum and bases of
right wings.
18. *Libellula auripennis,* adult, meso- and metapleurum, external.
19. *Libellula auripennis,* adult, metapleurum, internal.

Plate 43.

Fig. 20. *Mecistocephalus* sp., lateral view of a segment.
21. *Scolopocryptops* sp., fifteenth segment, lateral.
22. *Lithobius* sp., a large segment, lateral.

Fig. 23. *Cermatia forceps*, large pleurum of tenth double segment, lateral.
      24. *Spodromantis guttata*, dorsum of microthorax.
      25. *Spodromantis guttata*, microthorax and submentum, ventral.
      26. *Spodromantis guttata*, propleurum, external.
      27. *Spodromantis guttata*, mesopleurum, external.
      28. *Spodromantis guttata*, mesopleurum, internal.
      29. *Byrsotria fumigata*, propleurum, external.
      30. *Spodromantis guttata*, mesonotum, ventral.
      31. Mantid nymph, mesonotum, ventral.

PLATE 44.

Fig. 32. *Byrsotria fumigata*, female, mesosternum, mesopleura and coxæ, ventral.
      33. *Byrsotria fumigata*, female, mesopleurum, internal.
      34. *Byrsotria fumigata*, male, mesopleurum, external.
      35. *Ischnoptera hyalina*, mesopleurum, external.
      36. *Ischnoptera hyalina*, microthorax, dorsal.
      37. *Ischnoptera hyalina*, microthorax, ventral.
      38. *Blatella germanica*, metanotum, dorsal.
      39. *Microcentrum laurifolium*, metanotum, ventral.
      40. *Blatella germanica*, metanotum, ventral.
      41. *Microcentrum laurifolium*, mesonotum, ventral.

PLATE 45.

Fig. 42. *Anabrus simplex*, mesonotum.
      43. *Anabrus simplex*, male mesopleurum, external.
      44. *Anabrus simplex*, male, mesopleurum, internal.
      45. *Gryllus pennsylvanicus*, microthorax and labium, ventral.
      46. *Gryllus pennsylvanicus*, propleurum, prosternum and coxa, anterior.
      47. *Gryllus pennsylvanicus*, mesopleurum, mesosternum and coxa, anterior.
      48. *Gryllus pennsylvanicus*, upper end of metapleurum, internal.
      49. *Gryllus pennsylvanicus*, long-winged female, metanotum, ventral.
      50. *Gryllus pennsylvanicus*, short-winged female, metanotum, dorsal.

PLATE 46.

Fig. 51. *Melanoplus femur-rubrum*, prothorax, external, lateral.
      52. *Melanoplus femur-rubrum*, prothorax, internal, lateral.
      53. *Hippiscus phœnicopterus*, mesonotum.
      54. *Hippiscus phœnicopterus*, mesonotum, ventral.
      55. *Melanoplus* nymph, meso and metapleurum, internal.
      56. *Melanoplus* nymph, meso and metathorax and first two abdominal segments, lateral.
      57. *Hippiscus phœnicopterus*, metapleurum with bases of wing and leg, and first abdominal segment, lateral.

PLATE 47.

Fig. 58. *Melanoplus* nymph, meso- and metatergum.
      59. Mantid nymph, hind wing.
      60. Cockroach, diagram of hind wing.
      61. *Spodromantis guttata*, front wing.

Fig. 62. *Spodromantis guttata*, hind wing.
63. *Microcentrum laurifolium*, front wing.
64. *Microcentrum laurifolium*, hind wing.

PLATE 48.

Fig. 65. *Gryllotalpa borealis*, hind wing.
66. *Gryllus pennsylvanicus*, long-winged female, hind wing.
67. *Gryllus pennsylvanicus*, long-winged female, front wing.
68. *Dissosteira carolina*, front wing.
69. *Dissosteira carolina*, hind wing.

PLATE 49.

Fig. 70. *Dissosteira carolina*, mesopleurum, external.
71. *Dissosteira carolina*, mesopleurum, internal.
72. *Pteronarcys californica*, prothorax, lateral.
73. *Perla* nymph, prothorax, lateral.
74. *Perla* nymph, propleurum, internal.
75. *Pteronarcys californica*, mesotergum.
76. *Perla* nymph, metatergum.
77. *Perla* nymph, metathorax, lateral.

PLATE 50.

Fig. 78. *Pteronarcys californica*, metapleurum, external.
79. *Pteronarcys californica*, metapleurum, internal.
80. *Isogenus* nymph, mesopleurum, external.
81. *Acroneuria* nymph, mesopleurum, internal.
82. *Cerastipsocus venosus*, meso- and metapleurum, external.
83. *Benacus haldemanus*, prothorax, anterior, left coxa removed from coxal cavity (*CxC*).
84. *Benacus haldemanum*, part of inner surface of metapleurum showing epimeral coxal condyle (*k*) and true coxal condyle (*CxP*).
85. *Benacus haldemanum*, mesopleurum, external.
86. *Benacus haldemanum*, mesopleurum, internal.

PLATE 51.

Fig. 87. *Benacus haldemanum*, metatergum and first abdominal tergum, dorsal.
88. *Benacus haldemanum*, metatergum and first abdominal tergum, posterior.
89. *Benacus haldemanum*, metapleurum, external.
90. *Spongiphora apicidenta*, mesotergum and base of right elytron.
91. *Spongiphora apicidentata*, propleurum, prosternum, and base of leg, ventral.
92. *Spongiphora apicidentata*, mesotergum, ventral.
93. *Spongiphora apicidentata*, microthorax and bases of head and labium, ventral.
94. *Spongiphora apicidentata*, mesosternum and mesopleura, ventral.
95. *Buprestis aurulenta*, front of prosternum, microthorax, and base of head, ventral.

PLATE 52.

Fig. 96. *Spongiphora brunneipennis*, metatergum and first abdominal tergum.
97. *Cyllene robiniæ*, mesopleurum, external.
98. *Spongiphora apicidentata*, metapleurum, half of sternum, and base of leg.
99. *Buprestis aurulenta*, prothoracic coxa and trochantin.
100. *Spongiphora apicidentata*, metapleurum, internal.
101. *Cyllene robiniæ*, mesopleurum, internal.
102. *Calosoma scrutator*, mesopleurum, external.
103. *Calosoma scrutator*, mesopleurum, internal.
104. *Buprestis aurulenta*, mesothoracic coxa and trochantin.

PLATE 53.

Fig. 105. *Hydrophilus triangularis*, mesopleurum and sternum, external.
106. *Silpha surinamensis*, mesopleurum, external.
107. *Dytiscus dauricus*, mesopleurum, external.
108. *Dytiscus dauricus*, mesopleurum, internal.
109. *Buprestis aurulenta*, mesopleurum, external.
110. *Calosoma scrutator*, metapleurum, internal.
111. *Hydrophilus triangularis*, metapleurum, external.
112. *Hydrophilus triangularis*, metapleurum, internal.
113. *Calosoma scrutator*, metapleurum, external.

PLATE 54.

Fig. 114. *Dytiscus dauricus*, metapleurum, external.
115. *Dytiscus dauricus*, metapleurum, internal.
116. *Cyllene robiniæ*, metapleurum, external.
117. *Melolontha vulgaris*, metapleurum, internal.
118. *Dendroctonus valens*, metapleurum, external.
119. *Cyllene robiniæ*, metapleurum, internal.
120. *Dendroctonus valens*, metapleurum, internal.
121. *Melolontha vulgaris*, metapleurum, external.

PLATE 55.

Fig. 122. *Dendroctonus valens*, pupa, meso- and metaterga with wings, and first and second abdominal terga.
123. *Tetropium velutinum*, pupa, meso- and metaterga with wings, and first three abdominal terga.
124. *Dendroctonus valens*, unemerged adult taken from pupal skin, mesotergum and base of right elytrum.
125. *Hydrophilus triangularis*, mesotergum.
126. *Dendroctonus valens*, pupa, mesotergum and bases of elytra, ventral.
127. *Calosoma scrutator*, mesotergum and axillaries of right elytrum.
128. *Dytiscus dauricus*, mesotergum and axillaries of right elytrum.
129. *Cyllene robiniæ*, mesotergum, right axillaries, right parapterum and base of elytrum.
130. *Cyllene robiniæ*, mesotergum, ventral.
131. *Dytiscus dauricus*, mesotergum, left axillaries and base of elytrum, ventral.

Fig. 165. *Cimbex americana*, second parapterum of mesothorax and attached pronator muscle disk.
166. *Cimbex americana*, abdomen except first segment, which is fused with metathorax (164), lateral.
167. *Sirex flavipennis*, metapleurum, internal.

PLATE 62.

Fig. 168. *Pepsis* sp., propleurum and coxa.
169. *Pepsis* sp., thorax except propleurum and procoxa, which are removed (168), and base of abdomen, lateral.
170. *Pepsis* sp., mesotergum, lateral.
171. *Sirex flavipennis*, prothorax, lateral.
172. *Sirex flavipennis*, propleurum, internal.
173. Tipulid pupa, head, thorax, and base of abdomen, lateral.
174. *Holorusia grandis*, thorax, base of head, and base of abdomen, lateral.

PLATE 63.

Fig. 175. *Holorusia grandis*, mesotergum.
176. *Holorusia grandis*, upper end of mesopleurum.
177. *Holorusia grandis*, metapleurum and base of halter.
178. *Holorusia grandis*, mesopleurum, internal.
179. *Tabanus atratus*, thorax, lateral.
180. *Tabanus atratus*, protergum and mesotergum.

PLATE 64.

Fig. 181. *Libellula auripennis*, base of front wing.
182. *Pteronarcys californica*, base of front wing.
183. *Pteronarcys californica*, front wing.
184. *Pteronarcys californica*, hind wing.

PLATE 65.

Fig. 185. *Blatella germanica*, base of front wing.
186. *Blatella germanica*, base of hind wing.
187. *Dissosteira carolina*, base of front wing.
188. *Gryllus pennsylvanicus*, base of hind wing.
189. *Dissosteira carolina*, base of hind wing.

PLATE 66.

Fig. 190. *Benacus haldemanum*, base of front wing.
191. *Benacus haldemanum*, base of hind wing.
192. *Dytiscus dauricus*, base of wing.
193. *Calosoma scrutator*, base of wing.
194. *Cyllene robiniæ*, base of wing.

PLATE 67.

Fig. 195. *Melolontha vulgaris*, base of wing.
196. *Melolontha vulgaris*, wing.
197. *Calosoma scrutator*, basal parts of costa, subcosta, and radius, showing detached base of costa separated, ventral.

Fig. 198. *Hydrophilus triangularis*, base of wing.
  199. *Melontha vulgaris*, right axillaries separated, but in natural relative positions.
  200. *Corydalis cornuta*, base of front wing.
  201. *Corydalis cornuta*, base of hind wing.

PLATE 68.

Fig. 202. *Phassus argentiferus*, base of front wing and base of jugum (*Ju*).
  203. *Phassus argentiferus*, base of hind wing.
  204. *Protoparce cingulata*, base of hind wing with frenulum (*Fr*).
  205. *Cimbex americana*, base of front wing.
  206. *Sirex flavipennis*, base of front wing.
  207. *Sirex flavipennis*, base of hind wing.

PLATE 69.

Fig. 208. *Pepsis*, sp., base of front wing.
  209. *Pepsis* sp., base of hind wing.
  210. *Holorusia grandis*, base of wing.
  211. *Holorusia grandis*, base of halter.
  212. *Calliphora vomitoria*, base of wing with the two squamae of the alula (*Al*).

[NOTE.—Since this paper has been made up into pages the writer finds that he overlooked the fact that Riley (1904) ascribes a small part of the back of the head in *Blatta*, the " posterior maxillary pleurites " of Comstock and Kochi (1902) to the labial segment. If this is so then the microthoracic segment does play a small part in the formation of the head capsule.

As it was too late to put this in as a footnote on page 522, it has been inserted here.]